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REPORTS

May 1990 No. 297

A New Look at the Survey

Beginning with this issue, *Survey Reports* comes to you in a new format. Similar changes in other members of the Survey's family of publications—most notably the *Bulletin* and *Biological Notes*—will follow. We believe that by projecting a unified image our publications will heighten public awareness of the Survey and its important mission.

Readers, we hope, are attracted to the freshness and simplicity of the Survey's new design, both the unique block of type and the interesting symbol. We trust that these elements in combination will soon communicate the message—"from the Survey." Over time the symbol will establish its own denotative meaning, as all logos do. Those who look for a more immediate connotative value have suggested that the symbol represents a stylized eye that reminds us of the Survey's mission: to watch over the plant and animal resources of the state. That eye cannot be a particularly cheerful one because of the ever increasing rapidity with which species are lost from the planet and the growing list of threatened species. The symmetry of the symbol suggests the balance that must be achieved between the utilization and preservation of our living natural resources.

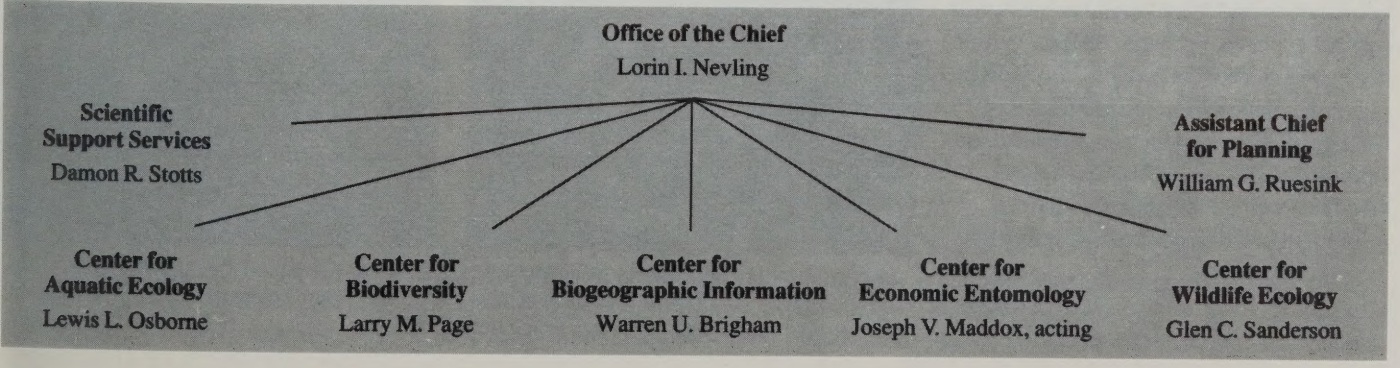
In the 132 years since its inception, the Illinois Natural History Survey has come to be recognized as the premier natural history survey in the nation, and many constituencies look to us for leadership. Over the course of the past year, we examined the organizational structure of the Survey to determine if it was the most efficient and effective to carry out our mission. We elected to follow the observation of Will Rogers, "Even if you're on the right track, you'll get run over if you just sit there." To that end we examined our programs and discussed our future in a systematic way. Our intent was to address the crucial issues of tomorrow in a time of fiscal restraint.

At the beginning of this fiscal year, we implemented the following organizational changes that we believe have both short- and long-term advantages.

The titles of the research units were changed from sections to centers and the titles of their leaders from section heads to center directors. Although this change is minor, we have moved both in concept and in terminology from a structure based on partition to one that emphasizes unity. A new administrative position, Assistant Chief for Planning, was established with the objective of helping the Survey to become responsive through planning rather than to be merely reactive.

The sections of Faunistics Surveys and Insect Identification and Botany and Plant Pathology were combined to form the Center for Biodiversity. We believe that botanists and zoologists working together in an integrated fashion within a single unit will have a synergistic effect on one another. This Center also brings together the major portion of public and professional services in the identification of species. In addition, the new arrangement brings the Survey's biological collections under unified management, a crucial step in ensuring their care and continuity.

Finally, a new unit was formed. The Center for Biogeographic Information was created in recognition of the increasing importance of computers to science and to the provision of biological information to state agencies and Illinois citizens. Placing our portion of the Illinois Geographic Information System and the Survey's computer network together creates an integrated computer environment. The unit also contains a service segment made up of contract staff, whose major function is to provide biological information to municipal, county, state, and federal entities. This information



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assists those agencies in making decisions about projected uses of the Illinois landscape.

Thus the Survey's new look is more than cosmetic, although our publications are experiencing a face-lift. We hope that readers are reminded of the long and proud history of the Survey when they see the solid, traditional block of type on the masthead, but we also hope that the contemporary look of the new logo conveys our acceptance of the challenges that are yet to be met if we are to safeguard the living resources of the state.
Lorin I. Nevling, Chief

Natural Areas, Rare Species, and Highways: Can They Coexist?

One regrettable aspect of the contemporary Illinois landscape is that in many parts of the state one can drive for miles and see no native plant communities or even many individual plants native to North America. The sad fate of the prairie in the Prairie State is well documented. Where formerly over 21,000,000 acres of prairie occurred, now only about 0.01% of that amount, or 2,300 acres, remain in high-quality condition (Illinois Natural Areas Inventory data). These remnants are found primarily as small, widely dispersed islands in an otherwise modified terrain dominated by nonnative species. Illinois lamentably ranks near the bottom among all states in the amount of land retaining an appearance of its natural condition.

Superimpose on this fragmented landscape a rural roadway system of more than 100,000 miles that is maintained by federal, state, and county governments and, despite the rarity of natural vegetation in Illinois, conflicts between highway construction and these fragile habitats will inevitably occur. For more than five years, staff at the Survey's Center for Biogeographic Information have been conducting biological surveys at the proposed sites of Illinois Department of Transportation (IDOT) projects. These studies have primarily been designed to determine the presence of natural areas, wetlands, and state and federally listed threatened and endangered species.

Although many IDOT project sites visited by Survey biologists do not contain habitats with a high degree of natural quality, some are important exceptions. Through a process of formal consultation between IDOT and the Illinois Department of Conservation (IDOC), the results of these studies have contributed to the protection of significant areas. The story of one such site is told below.

The Watseka Railroad Prairie, a noteworthy prairie remnant two miles in length, occurs in railroad right-of-way along U.S. Route 24 just east of Watseka in Iroquois County. Sands deposited on the shores of the Pleistocene-aged Lake Watseka and subsequently blown throughout the region have given a distinctive feature to the soils in the area. Although no deep sands were deposited in the prairie remnant, the soils are quite sandy and an interesting prairie community with characteristics of both black-soil and sand prairies developed on the site. Survey botanist Dr. Robert Evers (now retired) visited this site during the early 1960s, recognized its importance, and arranged for the Toledo, Peoria, and Western Railroad to leave this remnant undisturbed.

U.S. Route 24 is now scheduled for widening, and the design proposal called for elimination of about half the width of this already narrow prairie remnant. Records in the vascular plant herbarium at the Survey documented that Dr. Evers had collected a rare plant species, the state-endangered pink milkwort (*Polygala incarnata*), at this site and reported the presence of numerous plants at that time. Pink milkwort is a diminutive annual species that benefits from fire; however, this remnant had evidently never been managed with prescribed fire. One consequence of the suppression of fire in prairie remnants that occur in highway or railroad rights-of-way is the invasion of such alien grasses as meadow fescue and Kentucky bluegrass, which are planted along most midwestern roadsides. In the absence of fire, these European cool-season grasses eventually form a dense matrix that reduces the original species richness of the site.

Despite intensive searches of the remnant during 1986, no pink milkworts

The Watseka Railroad Prairie is located along U.S. Route 24 in Iroquois County. The state-endangered pink milkwort has been found on this site, one of only two or three known population of this species remaining in Illinois. Photos by John B. Taft.

were found. During 1987, a thorough inventory of the prairie was made (again no pink milkworts were found) and permanent plots were established to measure the response of the vegetation to prescribed fire. The first management fire was conducted the following spring, but no pink milkworts appeared during the drought of 1988 (native annuals, in general, fail to germinate without adequate soil moisture). A second burn occurred in the spring of 1989. Finally, on the last visit to the site (road construction is planned for 1990), a small population of pink milkwort was found in an area that had been searched repeatedly during previous years. This discovery documents one of only two or possibly three known populations of this prairie/savanna species remaining in Illinois. The IDOT has agreed to minimize disturbance to the highest quality prairie, the area that contains the pink milkwort population. In addition, seeds of prairie species collected from the site will be sown in areas of the Railroad Prairie where construction disturbances occur.

With the regular use of prescribed fire, there is hope that this population of *Polygala incarnata* will continue to recover. Continued monitoring of the site will permit us to correlate shifts in the composition of the prairie to the recovery of pink milkwort. In the case of this site, persistence was necessary to reverse the effects of years of fire suppression.

As proposed, several other highway projects have the potential to threaten valuable natural resources. Future biological surveys, like the survey at the site of the Watseka Railroad Prairie, will enable highway planners to develop designs that accommodate natural areas and the sometimes fragile habitats of threatened and endangered plants and animals.

John B. Taft, Center for Biogeographic Information

Periodical Cicadas to Emerge in Northern Illinois

Having been underground for more than a decade as nymphs feeding on the root sap of trees and shrubs, the adults of the periodical cicada, incorrectly called locusts by many people, will emerge in the spring of 1990 in northern Illinois. In the predawn hours of the last days of May through the first days of June, the inch-long, brown nymphs tunnel their way out of the soil and climb the trunks of trees (or other vertical surfaces). A few feet up the trunk, their skins split down the back and the lime green and white adults emerge. The brown shells of the nymphs remain on the trunk for several days before falling to the ground, where they eventually break apart.

Sitting head-upward on the trunk, the wet cicadas dry and their outside coverings cure and tan; their green and white bodies turn black, their eyes are red, and their clear wings are marked with orange veins.

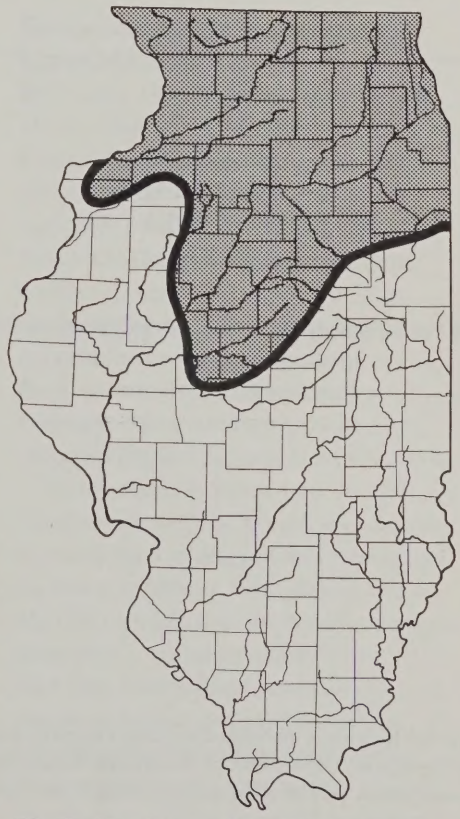
During sunny hours of the day, the males sing to attract the voiceless females to them. The 1¼-inch-long cicadas mate during June, and the females lay their eggs into slits that they have cut into the twigs and branches of trees and shrubs. When large numbers of cicadas are present, these slits can be numerous enough to kill some twigs and branches or weaken them so that they break off in the wind. Older trees and shrubs may appear to be severely damaged but will survive without lasting injury. Very young trees, those with trunk diameters of less than 1½ inches, may be killed or severely damaged.

The adult periodical cicada. Photo by Philip L. Nixon

Very young trees may need to be protected by covering them with screening, cheesecloth, or mesh bags such as those used in shipping onions. The mesh should be securely tied around the base of the trunk to keep cicadas from crawling underneath the mesh and up the trunk. Spraying trees with carbaryl, sold as Sevin, will protect them from attack for a few days. Unless trees are very small and a large number of cicadas are present, control measures will probably not be necessary.

Eggs that were laid in June hatch into nymphs six or seven weeks later; by this time the adults have died. These young nymphs drop to the ground, tunnel into the soil, and find a tree or shrub root on which to feed. Either 13 or 17 years will pass before these insects again appear above ground.

In June 1990, periodical cicadas will emerge north of a line running from Rock Island County south to northern Sangamon County and then north to northern



Distribution of the northern Illinois brood of periodical cicadas.

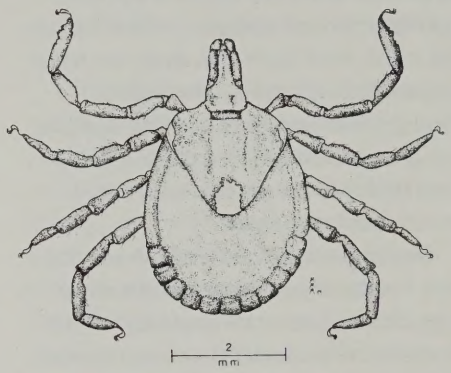
Iroquois County. These insects are a 17-year brood that last emerged in 1973. Other broods of cicadas occur in other parts of Illinois. Generally, cicadas in the southern half of Illinois go through a 13-year life cycle and those in the northern half experience a 17-year cycle. In central Illinois, some broods are from the shorter and others from the longer life cycle.

Annual or dogday cicadas are over 1½ inches long, larger than periodical cicadas. The adults are green or brown with black markings and appear each year from July to September but in smaller numbers than the periodical cicada. They tend to sing in the evening, about sunset. Their nymphs, like those of the periodical cicada, are brown but are over an inch long and usually feed on the sap of tree roots for two to five years.

Philip L. Nixon, Extension Entomologist

Lone Star Tick in Illinois

The tick most frequently submitted to the Survey for identification is the lone star tick, *Amblyomma americanum* (L.). This tick, a serious pest of humans, livestock, and wildlife in the southern United States, is well known as a vector of Rocky Mountain spotted fever and tularemia. Its common name derives from a prominent silvery white spot on the back of the female. The tick attacks humans in all of its active life stages (larva, nymph, and adult). The larvae often attack in clusters and are commonly known as "seed ticks."



Female lone star tick with its prominent back marking. Illustration by M.M. Makepeace, courtesy State Biological Survey of Kansas.

The adults and nymphs are prevalent in spring and early summer; the larvae generally appear later in summer.

The lone star tick was first detected in Illinois in the mid-1960s by Survey wildlife specialists studying white-tailed deer in southern Illinois. Deer are the most important host for the adult ticks, and heavy infestations can kill them. The lone star tick established itself across the Shawnee Hills region of southern Illinois and is familiar to residents there. In recent years it has been detected in a few scattered localities in central and northern Illinois. This recent extension of its range may be related to dispersal by the increasing populations of deer in the state. Entomologists at the Survey are monitoring the spread of this important tick, and readers of *Survey Reports* who encounter it in central and northern Illinois are urged to send specimens in alcohol to the Survey in care of the author.

John K. Bouseman, Center for Economic Entomology

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REPORTS

June 1990 No. 298

Invertebrate Drift in Streams

Anglers have long known that many stream fish feed extensively on animals drifting downstream on the surface or in the water column above the stream bottom. Most invertebrates (primarily immature stages of aquatic insects) that live on or in the bottom of streams and rivers can be found, at least occasionally, in the water column as they are transported downstream by the current. Drift is the term used both to describe these animals while they are in the water column and to refer to the process of being transported downstream. Despite the apparent importance of drift as a source of food for fish, little research had been done until about thirty years ago when two discoveries stimulated interest. First, most animals drift with a distinct periodicity. As a result, the number of animals in the drift is much greater at night than during the day. Second, the number of animals drifting past a given point during a 24-hour period can be appreciable, often greater than the number on the stream bottom immediately upstream of the sampling point. These observations raised several questions: Why do many species drift with diel (day-night) periodicities? How do animals enter the drift? Are they passively washed off rocks by current or do they actively launch themselves into the water column? Why do animals drift? What is the importance of drift in the population ecologies of animals that drift and of fish that consume drifting animals?

Fish are effective consumers of drifting invertebrates during the day but less so at night. Consequently, researchers have speculated that nocturnal drift evolved in many species to minimize the risk of being eaten by drift-feeding fish. Two lines of evidence support this hypothesis. First, small invertebrate species and small size classes of larger species tend to be less preferred prey of fish and often exhibit aperiodic drift. More convincing is the observation that strong periodicities are rare in fishless streams; however, invertebrates that exhibit no periodicity in fishless streams show strongly nocturnal drift in streams where drift-feeding fish are present.

Research on the evolution of diel drift periodicities does not answer the question of why animals drift, which is strongly tied to the question of how animals enter the drift. Although both passive and active entry likely occur, recent research supports the hypothesis that drift-entry is predominantly active and that this behavior is often associated with searching for food. Research is underway to determine if and how food abundance and body size interact to affect the probability that an individual will enter the drift. Animals rarely drift when food is readily available, but the probability of drifting increases exponentially with decreasing food abundance. Relationships such as these are being incorporated in simple colonization models to predict how animal densities on bottom substrates should change and equilibrate with changes in the surrounding environment and on the substrates. The models are tested in the field using time-lapse video cameras with infrared light sources (because insects, like humans, cannot see infrared light) so that animal behavior can be monitored during the day and night.

How interactions with other members of the stream community (e.g., competitors, predators) influence drifting is also being addressed. Competitors have been found to have a marked influence on drift, largely by affecting the availability of food for other individuals. By influencing drift rate, competitors can potentially affect food availability for drift-feeding fish and, consequently, the population dynamics of the animals with which they compete. Documenting the importance of these interactions in the structure of stream communities remains a major challenge to stream ecologists and requires continued modelling and experimentation.

Steven L. Kohler, Center for Aquatic Ecology

Environmental Management of the Upper Mississippi River

In October 1986 Congress approved the Master Plan for the Management of the Upper Mississippi River System, which includes the Illinois River and the navigable portions of the Kaskaskia. The Plan is the first in the nation to address conflicting federal mandates for large interstate rivers and to redress habitat degradation caused by alterations within the rivers and their drainage basins. Programs based on this model are now proposed for the Missouri and Ohio rivers.

As stipulated in Public Law 99-662, *The Secretary [of the Army], in consultation with the Secretary of the Interior and the states of Illinois, Iowa, Minnesota, Missouri, and Wisconsin, is authorized to undertake . . . (A) a program for the planning, construction, and evaluation of measures for fish and wildlife habitat rehabilitation and enhancement; (B) implementation of a long-term resource monitoring program; and (C) implementation of a computer inventory and analysis system.*

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The Plan grew out of a deadlock between navigation interests and the U.S. Army Corps of Engineers on one side and conservation advocates and the U.S. Fish and Wildlife Service on the other. At issue was the replacement of the locks and dam on the Mississippi River at Alton, a choke point for barge traffic moving upstream of St. Louis on both the Mississippi and Illinois rivers. Navigation interests wanted the new locks to have a much greater traffic-carrying capacity; conservationists, on the other hand, argued that existing traffic was already adversely affecting fish and wildlife and that the new locks should have no greater capacity than the old. After a lawsuit in the U.S. Federal Court in Washington, D.C., in 1974 and debate in Congress, a compromise was reached in the 1986 Master Plan.

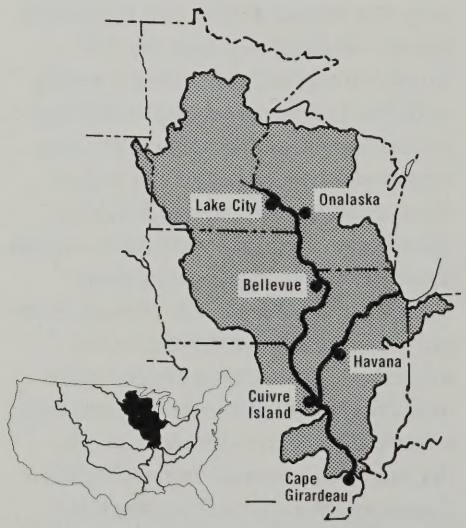
Developers of the Plan recognized that existing information on the Upper Mississippi River was insufficient to determine the environmental impact of increased barge traffic and an associated increase in river terminals. Instead of waiting for this information to be collected, however, they compromised, allowing construction of the replacement locks and dam to begin but at the same time authorizing programs that would collect the needed information.

Two of these programs, the Long-term Resource Monitoring Program and the Computerized Inventory and Analysis System, document upstream/downstream and year-to-year trends in selected natural resources of rivers. Short-term studies relate environmental effects to causes. The third program, Habitat Rehabilitation and Enhancement, evaluates restoration techniques in areas where fish and wildlife habitats have become degraded.

The ten-year Plan has yet to reach its authorized budget of $20 million per year, but Congress has increased appropriations for it each year since 1986. The budget for 1990 is $14.9 million. Although the total cost of $200 million is large, it is only a fraction of the $1 billion price tag on the new locks and dam at Alton. Ideally, these programs will continue beyond the authorized ten years, perhaps through a combination of state and federal funding and user fees. Only after initial investigations determine what restoration methods are feasible can the work of rehabilitation begin. In addition, the rivers will continue to change and the data base is likely to prove increasingly useful in the future.

The Natural History Survey and several other Illinois agencies have been closely involved with the Master Plan from the initial fact-finding associated with the court case, through the early planning stages, to its implementation. The River Research Laboratory at the Survey's Stephen A. Forbes Biological Station on the Illinois River at Havana is part of a network of six state-operated field stations that collect and analyze data on fish populations, vegetation, and water quality for the Long-term Resource Monitoring Program. In addition, Survey research biologist Pamela Tazik is an advisor on vegetation sampling at the station operated by Western Illinois University at Cuivre Island on the Mississippi.

Together the six stations collect data from seven major reaches—the first year-round biological sampling at a scale commensurate with the size of the Upper Mississippi River System. Each reach includes permanent channels and lakes and transition zones on the floodplains that alternate between wet and dry. The sampling sites represent the spatial heterogeneity that is characteristic of large, complex river-floodplain systems. The temporal scale, too, is appropriate for the system under study: ten years is long enough for trends to emerge from the "noise" of short-term variations.



The six monitoring stations along the Illinois and the Upper Mississippi rivers are shown above. The shaded area indicates the boundaries of the Upper Mississippi Subbasin, which is also shown on the inset map of the United States.

In addition to comparing patterns in field data and elucidating causes by correlation, researchers will monitor one or more habitat rehabilitation projects in each study reach. In the process, they will collect data before, during, and after large-scale experimental manipulations. Such manipulations are common in ecological studies of small streams but not in larger systems with their conflicting uses and diverse management.

The cooperative, cost-sharing agreements among the many state and federal agencies are one of the remarkable aspects of the rehabilitation and monitoring programs. The Master Plan for the Management of the Upper Mississippi River System with its programs of habitat rehabilitation, long-term monitoring, and computerized analysis will contribute to our understanding of large floodplain rivers and should help state and national entities to manage the competing uses of the river resource.

Richard E. Sparks, River Research Laboratory, Forbes Biological Station

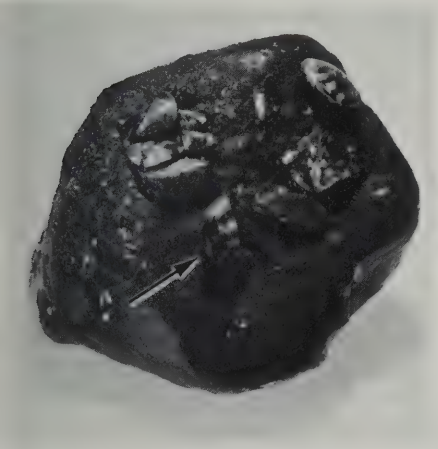
The Zebra Mussel: Exotic Invader

Exotic or nonindigenous species play a significant role in the changing biodiversity of Illinois and the world. While some introduced species may be perceived as successes, the vast majority have proved detrimental to native plants and animals. The sea lamprey and Asian clam (*Corbicula*), for example, invaded our inland waters and cost taxpayers millions of dollars in attempts at eradication and control. Yet another exotic, the zebra mussel (*Dreissena polymorpha*) has entered portions of the Midwest and now threatens to spread into Illinois.

The zebra mussel, a small mollusk native to the Black, Caspian, and Azov seas of Eastern Europe, is 1–2 inches in length and resembles the common blue mussel (*Mytilus edulis*) of U.S. coastal waters. Although variable in color, the zebra mussel is typically cream-colored with brown bands, hence its common name. Its presence raises immediate concern because of its negative effects on the native biota and on water supply (treatment plants, power plants, and other facilities that use surface water). Potential costs associated with the *Dreissena* invasion have been estimated at $500,000,000 a year for the next ten years.

Zebra mussels were first discovered in North America in June 1988 in southern Lake St. Clair between lakes Huron and Erie. The introduction most likely occurred in 1985 or 1986 with the discharge from ocean-crossing ships of freshwater ballast that contained the free-swimming zebra larvae. The mussel now infests lakes St. Clair and Erie and has spread into the western end of Lake Ontario. In the spring of 1989 a few mussels were found on a navigation buoy in Green Bay, Lake Michigan.

The expansion of populations of zebra mussels in Europe and in the Great Lakes is attributed to high fecundity, the presence of a free-swimming larval stage, and the lack of predators. Tough fibers, called byssal threads, enable these mussels to attach to solid objects and form large, dense colonies. Common objects for attachment are rocks, intake pipes, buoys, and boat hulls but also include freshwater mussels, crayfishes, and even each other. Colonies of over 100,000 individuals per m^2 have been reported. Zebra mussels filter large amounts of water under optimal conditions, and rates of approximately 1 liter per day per mussel have been reported. As filter feeders on plankton, they could have a devastating effect on the food source of many fishes and other species.



Zebra mussels colonizing a rock collected from Port Arthur, western Lake Erie, in 1989. The mussel in the foreground is 7 mm in length.

Because of the ability of the zebra mussel to attach to nearly any submerged object, it is expected to expand its range rapidly in the United States and Canada, moving out of the Great Lakes and into any number of streams. Following its arrival in Lake Michigan, it will likely invade the Upper Mississippi River Basin via the Chicago Sanitary and Ship Canal and Illinois River. To date no reports of the zebra mussel in Illinois waters have been made, but its arrival appears to be a foregone conclusion.

Attempts to eradicate this pest have proved unsuccessful in Europe, and control methods—biological, chemical, and physical/mechanical—have met with varying degrees of success. Biological control includes the use of natural predators such as fishes (e.g., the mollusk-eating freshwater drum), diving ducks, and crayfishes. Although relatively promising as a control measure, predation has not been effective in eliminating zebra mussels. Chemical control, including the use of chlorine, tributyl-tin-oxide, copper, cyanuric acid, ozone, and ammonium nitrate, has been used but is potentially dangerous to the environment. Physical and mechanical control measures consist of sealing pipes, using deep water intakes, introducing heat treatment, using micro-screens to filter larval mussels, and flushing and scraping pipes to remove attached mussels.

To prepare for the invasion of the zebra mussel and its consequences, the Survey formed an interdisciplinary task force, sent representatives to a national symposium on the zebra mussel, and conducted an exhaustive literature search to obtain background information. Nearly 300 scientific publications and reports, mostly European in origin, were reviewed. Although the Survey is prepared to provide information related to this problem, it is unlikely that Survey scientists or anyone else will be able to eliminate the zebra mussel from North American waters or to control its expansion for an indefinite period. Expansions of other nonnative species that eventually proved to be pests—the common carp, house mouse, house fly, European starling, and house sparrow—could not be stopped, and their populations are controlled only through expensive and time-consuming methods. Unfortunately, the zebra mussel is likely to do a great deal of environmental and economic damage and, based on the management history of similar pests, we will be able to do little by way of intervention.

Many other potential pests are available for introduction into North America, especially from Europe where species have adapted to degraded environments and would be able to outcompete native North American species. One of the challenges of the next decade is to foster a new appreciation of the value of a healthy environment, especially one dominated by native species, and to develop legislation that will prevent the introductions of exotic species.

Kevin S. Cummings, Center for Biodiversity, and Michael R. Jeffords, Center for Economic Entomology

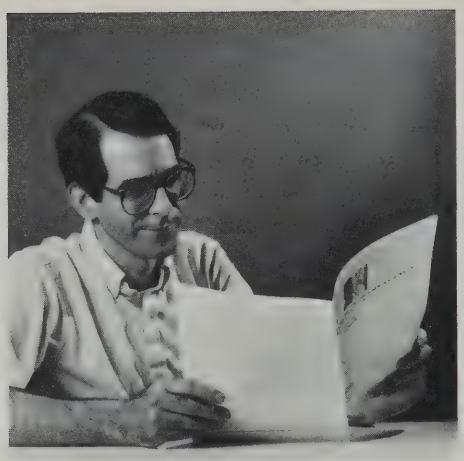
Corn Rootworm Bibliography Updated

The northern and western corn rootworms are the most serious insect pests of field corn in the Midwest and Canada. Costs for soil insecticides to control larval damage to the root systems of corn and aerial sprays to reduce beetle damage to corn silks, when combined with the associated crop losses, can approach $1 billion annually. Currently, soil insecticides for corn rootworm control are applied each

year to 50–60 percent of the corn acreage in the United States, and corn has replaced cotton as the crop receiving the largest amount of insecticides.

In 1974, the Survey published a bibliography of the northern and western corn rootworm. An update through 1976 followed in 1977. In the thirteen years since that publication, the literature on these two insects has grown immensely. Because ready access to this extensive literature is essential if researchers are to develop new control tactics, Eli Levine and Siu Yau Chan undertook the task of updating those earlier bibliographies. Their work has recently been released as Biological Notes 135, *A Bibliography of the Northern and Western Corn Rootworm: An Update 1977 through 1988.* Unlike its predecessors, this publication features an index of key words that permits quick retrieval of desired references. Copies of this bibliography as well as the two earlier publications (Biological Notes 90 and 101) may be obtained from the Survey. The cost of each is $2.00.

Eli Levine, Center for Economic Entomology and University of Illinois



Eli Levine looks through the recently updated bibliography on the corn rootworm, Biological Notes 135.

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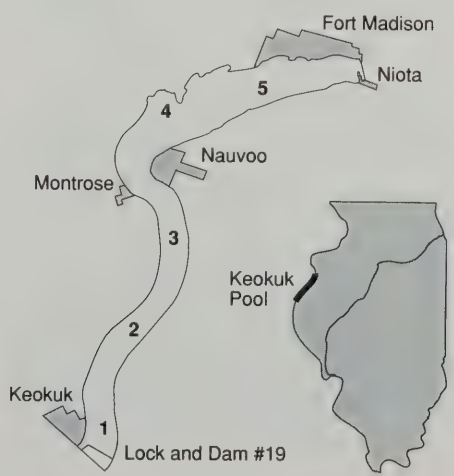
September 1990 No. 299

Human Disturbance of Waterfowl

The distribution and behavior of diving ducks on migration areas in the Mississippi Flyway are affected by human disturbances, particularly those related to boating. Staging areas in which waterfowl can feed without disturbance are crucial during the fall migration because the fat reserves built up by ducks at these food-rich areas help to condition the birds for winter. Further, when ducks feed leisurely on these areas in the fall, they place fewer demands on sparser wintering grounds. Staging areas free from disturbance are also important during the spring migration because reproduction places heavy demands on the energy reserves of female ducks. Keokuk Pool on the upper Mississippi River is one of these important staging areas for migrating waterfowl, especially diving ducks.

In spite of the limited number of high-quality staging areas, the use of Keokuk pool by diving ducks has been declining. To determine whether this reduced use is related to disturbances by humans, ecologists at the Natural History Survey along with their counterparts at Western Illinois University undertook a study in which three categories of disturbance were observed: disturbances related to boating (including fishing, hunting, and recreational boating), barge, and shore activities. The reactions of waterfowl and boats to these disturbances were monitored during the fall of 1986 and 1987 and the spring of 1987 and 1988 on a 30-km segment of Keokuk Pool from Keokuk to Fort Madison, Iowa. Thirty-minute observations of waterfowl use, human disturbance to waterfowl, and reaction of waterfowl to disturbance were conducted at five sites in a random sequence during mornings and afternoons on weekdays, weekends, and holidays. Observations were taken for 124.5 hours in the fall of 1986 and for 123.5 hours in the fall of 1987. In the spring of 1987, observations were taken for 75 hours; 100.5 hours of observation were made in the spring of 1988. During the two periods of fall observations, 110 disturbances were recorded; 92 disturbances were recorded during the two spring observations.

Boating activity was responsible for 79 percent of the recorded disturbances in the fall of 1986 and for 73 percent in the fall of 1987. In the spring of 1987, boating accounted for 59 percent of the recorded disturbances; the figure for the spring of 1988 was 70 percent. Boating activity associated with hunting accounted for 26 and 36 percent of the disturbances during the fall of 1986 and 1987, respectively, with 35 and 56 percent of these disturbances occurring during the respective hunting seasons of those years. Boating activity related to fishing caused 31 percent of the disturbances in the fall of 1986, 18 percent in the fall of 1987, 44 percent in the spring of 1987, and 35 percent in the spring of 1988.



Numbers indicate the five observation sites in the Keokuk Pool study area.

Waterfowl use was highest at site 4 near Nauvoo and site 5 between Nauvoo and Niota; however, the rate of disturbance (number of disturbances per hour of observation) was also high at these sites. Site 5 experienced 1.3 and 0.7 disturbances per hour during the fall of 1986 and 1987, respectively, and 1.6 and 0.6 disturbances per hour during the spring of 1987 and 1988, respectively. When computed for daylight hours, these rates equal 14 disturbances a day in fall 1986, 8 in fall 1987, 21 in spring 1987, and 7 in spring 1988. The overall rate for the five sites was 0.5 and 0.4 disturbances an hour (approximately 6 and 4 disturbances a day during daylight hours) for the fall of 1986 and 1987, respectively, and 0.6 and 0.5 disturbances an hour (approximately 8 and 6 disturbances a day during daylight hours) during the spring of 1987 and 1988, respectively.

The declining use of Keokuk Pool by diving ducks and the rates of disturbance documented in this study are cause for concern—particularly when we consider that continental populations of lesser scaups (*Aythya affinis*), canvasbacks (*A. valisineria*), and redheads (*A. americana*) have fallen below their long-term averages and are lower than the numbers established for them in the North American Waterfowl Management Plan. The data argue strongly that an experimental refuge inviolate to boating be established where feasible between Nauvoo and Niota during the fall and spring migrations. Further monitoring, especially of diving ducks, will be required in those areas.

Stephen Havera, Forbes Biological Station, Center for Wildlife Ecology

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Cleaning up Pesticide Waste

The use of pesticides has received intense scrutiny since the late 1940s. More recently, concern has focused on pesticide waste, which is generated by farmers and urbanites alike. A case in point is the finding by the Illinois Environmental Protection Agency (IEPA) and the Illinois Department of Public Health of unusually high concentrations of pesticides in soil and wells at agrochemical retail facilities. The contamination is likely due to a combination of spills and the uncontrolled drainage of water used to rinse pesticide application equipment. Analogous problems may exist at private residences.

Recent research indicates that biodegradable pesticides are extremely persistent when present in the soil at unusually high concentrations. When a business has a major contamination incident, the IEPA can order a cleanup, which is very costly. Such expenses are prohibitive to small businesses and individual homeowners. More problematic is the nature of the cleanup. Contaminated soil is excavated and removed to a "secure" landfill. The end result is perhaps a cleaner site, but the waste has not been detoxified.

New approaches that are consistent with the ubiquity of pesticide waste are needed for cleanup in situ. Decontamination by microorganisms has been recognized as a potential technology for detoxifying chemical wastes. Several strategies have been suggested to develop microbial decontamination systems: (1) pretreatment of contaminants with various reagents to produce degradates more amenable to microbial mineralization; (2) treatment of wastes with microbial enzymes; (3) amendment of contaminated soil with additional nutrients to stimulate natural microbial activity; (4) inoculation of wastes with adapted microorganisms; (5) combinations of these strategies.

With funding from the Illinois Hazardous Waste Research and Information Center, Drs. Allan Felsot and Kudjo Dzantor in the Survey's Center for Economic Entomology are studying methods for enhancing the biodegradation of herbicide waste in soil. They have isolated from contaminated soils microorganisms that have the potential to detoxify low-to-moderate concentrations of the herbicide alachlor. Some strains can detoxify alachlor when present as a sole carbon source at low levels; other strains can detoxify alachlor at higher levels if such nutrients as glucose or yeast extract are present. The degradative abilities of the microbial isolates are being enhanced using a combination of three procedures: breeding, selection for resistance, and mutagenesis.

In the first procedure, breeding, two or more microbial strains possessing complementary metabolic pathways for alachlor degradation are cultured together. The strains exchange genetic information, and a new strain with a combination of the desirable characteristics of the parent strains may evolve. In preparation for these breeding experiments, the ability of bacterial isolates to degrade model metabolites of alachlor is being studied.

In the second procedure, selection for resistance, microbial isolates are grown in the presence of toxic concentrations of alachlor. Bacterial colonies that survive on these toxic doses are selected from the growth medium, cultured on nutrient-rich media, and again selected for resistance to toxicity. These resistant strains should possess an enhanced capability to degrade alachlor. Initial studies show that alachlor is toxic to bacteria at concentrations greater than 100 ppm. Recently, a bacterial strain was selected to grow on a solid medium containing 10,000 ppm (1% by weight) of alachlor. This strain is now being tested for its ability to degrade alachlor in solution.

Dr. Allan Felsot examines bacterial colonies to determine how well they survive toxic doses of alachlor.

The third procedure, mutagenesis, is commonly used to create "libraries" of bacteria that possess various metabolic traits. Bacteria that can degrade low levels of alachlor as a sole carbon source are selected and exposed to mutagens for a short period. These bacteria are then grown on media that contain alachlor and survivors are tested for the ability to degrade alachlor. An enhanced ability would presumably be due to a mutation in the gene that encodes the enzyme that detoxifies alachlor.

When enhanced microbial isolates are obtained, they can be inoculated directly into contaminated soil to detoxify the waste. Drs. Felsot and Dzantor are also determining the effect of the addition of nutrients on the rate of alachlor degradation. Thus far they have found that ground corn and soybean residue stimulate a several-fold increase in the rate of alachlor degradation. The ultimate goal is to use a combination of nutrient amendments and bacterial inoculation to clean up contaminated soil in situ, thereby avoiding the expense of removing the soil and the hazard of storing it in landfills.

Allan Felsot, Center for Economic Entomology

Survey Launches Tree Care Program

In cooperation with the Department of Horticulture, University of Illinois at Urbana-Champaign, the Survey launched a major new educational program for tree care specialists. Initiated last December, the program is expected to be in place by the summer of 1991. Tree health care rather than crisis treatment is its focus, with particular emphasis on Integrated Pest Management (IPM).

Tree care professionals, unlike their counterparts in the medical profession, have tended to resist the idea of health care programs—the preventive medicine of the arborist. It has been their experience that customers wait until a crisis develops and then expect an immediate cure. Arborists also believe that customers are unwilling to pay for preventive care.

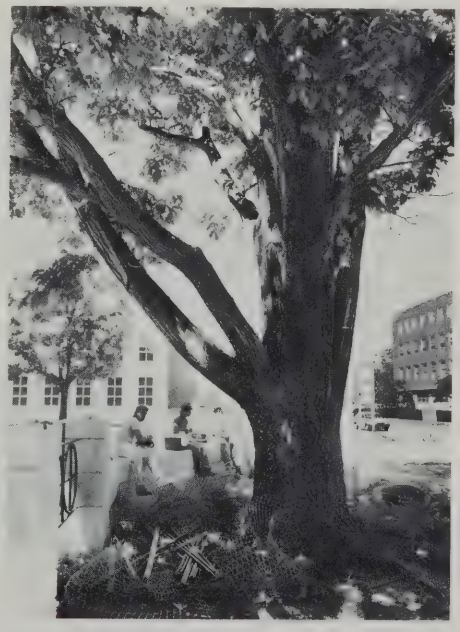
Perhaps the most important explanation is that tree specialists are poorly informed about tree health care programs and IPM.

Trees have made the headlines in recent months, particularly urban trees. A much publicized tree planting effort by the U.S. Forest Service is designed to help ward off the greenhouse effect, reduce air pollution, improve property values, and provide shade, thereby reducing the energy used for air conditioning. While the reforesting of America's cities is welcomed by tree care firms, environmentalists, and city dwellers alike, trees in urban settings have more problems than their forest cousins. Ill-chosen sites, inappropriate choice of cultivars, damage from lawn care activities, soil compaction, improper or inadequate fertilization, increased temperatures in city environments, and insufficient water or poor drainage all play a role in the increased predispostion of urban trees to disease and to damage from insects and mites. If the urban forest is to thrive, tree care professionals must be prepared to respond to these problems. The response, however, cannot be merely more applications of an increasing number of pesticides. Over the past several years, the public has begun to take a stand against the release of toxic substances into the environment and several states, including New York, Massachusetts, and Illinois, now have regulations that reduce the exposure of homeowners and their neighbors to pesticides used in lawn and tree care. IPM offers an alternative method of pest control with a reduction in the use of pesticides.

The first phase of the Survey's educational program, completed in February, investigated why IPM has been avoided by tree care firms and resisted by customers. A survey of residential customers of tree care firms found that tree owners were not generally opposed to the blanket spraying of trees on their property and that many of them would not be willing to pay higher costs for IPM. Those surveyed acknowledged that IPM is safer for the environment but nevertheless preferred the quick results of traditional methods. Property managers shared many of the attitudes expressed by residential customers but were more likely to recognize the hazards of pesticide use and more likely to question a tree care firm about the safety of its methods.

A survey of tree care firms also proved enlightening. The most important finding was that tree care professionals were poorly informed about IPM. Few arborists, for example, trap and release biological control agents and most did not know how to use such management strategies and were concerned that released insect parasites and predators would not control pest problems. Arborists did, however, favor spot treatment and selective spraying as opposed to blanket spraying, and many have begun to perceive the value of integrated methods.

Phase two of the program saw the completion in June of a bibliography of tree health care literature. Its nearly 2,000 references are entered in a computer data base and will be available as a software package and in a printed version. Each entry includes author, date, title, and information on how to locate the material. Citations are indexed by such general categories as tree diseases, insect damage, and cultural practice. These categories are further divided by specific disease or insect or host and by geographic location. In addition to the more traditional kinds of references, the bibliography cites videos, sets of slides, fact sheets, and publications available from extension services, state departments of agriculture and forestry, arboretums, and private industry. Many of these publications are serial or frequently updated and are excellent sources of information on the life cycles of pests, optimum times to control pests, and cultivar selection for specific geographic areas. This is the kind of information that tree care professionals must have if they are to train their employees to use IPM tactics and educate their customers to pay for them.



Trees in urban settings have more problems than their forest cousins.

In phase three of the project, eighteen tree care firms that are already implementing IPM were interviewed. The information gleaned will help to determine which IPM practices are cost effective. Of even greater importance, the results of these interviews should suggest how other firms can go about initiating IPM.

Phase four featured a discussion workshop for researchers and arborists who practice IPM. From this exchange will come a video illustrating how an IPM program works. This video will become part of a training package and is intended to send a persuasive message to arborists resistant to or uninformed about IPM.

In phases five and six, the information and insights obtained from earlier phases will be incorporated into training materials for tree care professionals, their employees, and their customers. Workshops and such educational materials as manuals, videos, and slides will describe the benefits of a programmatic approach to tree health care. Particular emphasis will be given to eliminating the misconceptions revealed in phase one. The final product will be an educational package that will enable tree care professionals to successfully incorporate the tenets and practices of IPM into their businesses.

Anne Dorrance, Center for Biodiversity

Long-term Resource Monitoring

In September 1989 the River Research Laboratory of the Forbes Biological Station at Havana began monitoring water quality once a week in the channels, channel borders, backwaters, and floodplain lakes of the LaGrange Pool of the Illinois River, thereby joining a network of six field stations that are collecting long-term data on the upper Mississippi and Illinois rivers. Because this network of stations uses standardized methods to collect and report data, upstream-downstream and year-to-year trends can be detected and comparisons made between the Illinois and Mississippi. Sampling of fish populations and vegetation began in June 1990, and the sampling of benthic macroinvertebrates will probably begin in January 1991.

Water-quality data already indicate the value of frequent sampling in habitats that are important to aquatic life but were not sampled previously because they were relatively inaccessible or because funds or personnel were insufficient to permit more than monthly sampling from bridges over the main channel. Peaks of turbidity in lakes and backwaters are episodic and clearly related to waves generated by windstorms or resuspension and lateral movement of sediments by towboats operating in the main navigation channel. When vegetation and fisheries data become available later this year, relationships between such factors as turbidity, aquatic vegetation, and fish catch can be quantified.

One surprising finding was the sporadic occurrence of high pH values (8.9) this spring. Ammonia occurs in the sediments and waters of the Illinois River, and the higher the pH, the greater the proportion of un-ionized ammonia, the form that is toxic to aquatic animals. A total ammonia concentration that is harmless at a pH of 7.5 can kill fish and aquatic invertebrates at higher pH values, depending on how long the elevated pH persists. High values may have been caused by spring algal blooms (probably diatoms), which use nutrients made available during the beginning of the spring flood and which raise the pH by removing carbon dioxide from the water. Other research has shown that late winter and early spring are stressful times for overwintering fish, and elevated concentrations of un-ionized ammonia may turn out to be a causal factor.

Because the Long-term Resource Monitoring Program calls for year-round sampling for the next six years, confirmation and follow-up of these early results will be possible.

Richard Sparks and Douglas Blodgett, Forbes Biological Station, Center for Aquatic Ecology

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REPORTS

October 1990 No. 300

Badger Alert!

The Survey is beginning the second year of a study of the badger (*Taxidea taxus*) in Illinois. Funded by the Illinois Department of Conservation and the U.S. Fish and Wildlife Service, the project addresses the status and ecology of badgers in the Midwest. Although trapping records can be used to reconstruct historical trends in the abundance of many fur-bearing mammals, such data for badgers in the Midwest are lacking. At the time badgers could be legally trapped, they were of limited and sporadic importance in the fur market. As a result, the take of pelts was irregular and trends in abundance were not well documented. Because scattered evidence indicated that badger populations were declining after World War II and because badgers have few natural predators except for humans, most midwestern states, including Illinois, have granted badgers protected status in recent decades.

Over the past ten years, sufficient evidence has been compiled to indicate that badgers are present in most counties of Illinois, and work at present focuses on delineating the primary badger range within the state. In addition, biologists hope to study the ecology of badgers intensively in several regions of the state that represent various environmental conditions.

The ecological, morphological, and physiological adaptations of this carnivore are of considerable biological interest. Badgers breed in midsummer, and delayed implantation of embryos occurs in January or February. One to four young per pregnant female are born in early spring. The badger is a truly fossorial (adapted to digging) mammal, and few such mammals are found in North America. Some of its adaptions include a wedge-shaped head on a short neck; large nictating membranes that protect the eyes from dirt; short, erect ears also protected from dirt by long hair; very muscular forelegs; partially webbed toes; and two-inch curved claws with pressure receptors (Pacinian corpuscles). The badger has unusually loose skin, a trait responsible for anecdotal refernces to a badger "turning around in its skin."

Although their physiological adaptations are unique, badgers are better known for their pugnacious personality. Many rural inhabitants of Illinois during the early 1900s relish a story or two regarding their encounters with this animal. Badgers are indeed relatively solitary and seem more than willing to hold their ground with any mammal that disturbs them. For humans, however, badgers are more bark than bite—unless cornered. Other mammals that encounter badgers and are willing to remain in the vicinity are likely to become the badger's next meal, especially if they are burrowing mammals, or to be the recipients of a charge—feigned or real—accompanied by an impressive array of vocalizations including hisses, snarls, and barks!

Because badgers are primarily nocturnal, they rarely come in direct contact with humans. Their presence usually goes undetected unless they dig extensively near human residences in search of prey or a den site. Although extensive digs can be found, in many cases badgers quickly

The status of the badger in Illinois has been poorly understood, but preliminary research suggests that it is widespread throughout the state in relatively low numbers. Line drawing by Beverly Anderson.

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deplete the available food resources and move on within days or weeks. In fact, the highly transitory behavior of badgers in Illinois has proved frustrating to Survey biologists, and active badger sites are being sought for study. If readers of *Survey Reports* are aware of sites, we encourage them to contact the Survey by mail or, preferably, by phone (217-333-5199). With the "here today, gone tomorrow" tendency of badgers, researchers will make every effort to inspect reported sites as soon as possible. *Richard E. Warner, Center for Wildlife Ecology*

The state-threatened migrant loggerhead shrike (*Lanius ludovicianus*) shares its habitat with the Joliet Army Ammunition Plant in Will County. This migrant species is shown above with its nest in osage orange. Nest photo by Alfred O. Gross; bird photo by Richard R. Graber.

Endangered Species and the U.S. Army

Extinction is a natural response to changing ecological conditions. Changes wrought by humans and their activities, however, have generally accelerated this process over the past century. Although habitat destruction is the principal threat to most species, other factors include exploitation of a species, the introduction of new species into an area, and pollution of soil, water, and air.

The Endangered Species Act, passed by Congress in 1973, provides protection for species on the verge of extinction. At the federal level, an endangered species or subspecies is defined as one in danger of extinction throughout all or a significant portion of its range. A threatened species or subspecies, on the other hand, is one likely to become endangered within the foreseeable future. Federally listed species are designated by the U.S. Fish and Wildlife Service. In Illinois, the Department of Conservation lists as endangered any species in the state in danger of extinction as a breeding species. Species likely to become endangered within the foreseeable future are considered to be threatened.

Section 7(a) of the Endangered Species Act (Public Law 97-304) requires all federal agencies to implement programs for the conservation of threatened and endangered species on or adjacent to their property. The U.S. Army, for example, has specific regulations to protect such species on army installations. Regulation AR420-74 requires installation commanders to assure that the existence of threatened and endangered species will not be jeopardized. It also stipulates that an inventory be made of all such species and their habitats that are indigenous to or dependent on installations. Species that appear on either federal or state lists must be protected.

In cooperation with the Construction Engineering Research Laboratory (CERL) of the U.S. Army Corps of Engineers, researchers at the Survey's Center for Aquatic Ecology are completing an annotated directory of threatened and endangered animal species found on U.S. Army installations east of the Mississippi River. This publication will not only assist army personnel in the identification of threatened or endangered species found on installations but will also help army planners to minimize threats to these species. In addition to known occurrences on or near installations, life history information and management guidelines for these species will be included in the directory.

Each of the 47 installations listed in the directory has unimproved grounds of 50 or more acres. Combined, they total almost two million acres. Because installations are often located along coastlines, in agricultural regions, or near urban areas, they sometimes encompass the last large remnant of a disappearing habitat. In Illinois, for example, bald eagles nest and winter in areas of the Savanna Army Depot in Carroll and Jo Daviess counties. The white-tailed jackrabbit and the river otter, state endangered and threatened species respectively, have also been seen on the installation. State and federally listed mollusks may be found in the Mississippi River adjacent to the installation as may threatened or endangered species of herons, egrets, and fish in the marsh areas of the installation. The bald eagle also winters on the Joliet Army Ammunition Plant in Will County, and the state-endangered upland sandpiper and northern harrier and the state-threatened migrant loggerhead shrike share that installation. State and federally listed mollusks have also been recorded in the Illinois and Kankakee rivers near this base.

Much of the information used to create this directory comes from the Natural Heritage Programs of the states east of the Mississippi. These programs, part of the Nature Conservancy, generally maintain data bases on the distribution of plants and animals throughout their respective states. Other data are being obtained from the U.S. Fish and Wildlife Service, from various natural resource agencies of the states, and from the general literature. In addition, a few army installations already had well-developed wildlife management programs in place.

In 1989 the signing of a cooperative management agreement between the Department of Defense and the Nature Conservancy greatly enhanced efforts to

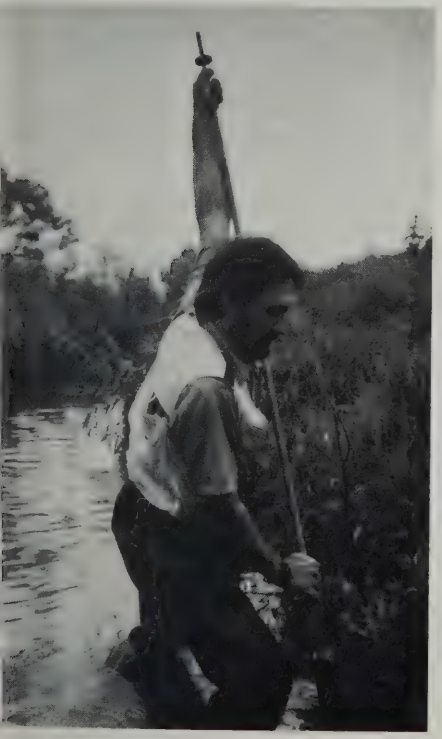
preserve biological diversity on the 25 million acres of land controlled by the Department. This agreement enables the Conservancy to work directly with the Department in the effort to identify and preserve biodiversity on army installations across the country. The directory will undoubtedly play an important role in this cooperative endeavor.

Renée Sherman, Center for Aquatic Ecology

Standardizing Annelid Nomenclature

In 1981 the American Fisheries Society (AFS) established the Committee on Names of Aquatic Invertebrates. Its charge is to achieve standardization of the scientific and vernacular nomenclature of aquatic invertebrates. To date two volumes, one devoted to mollusks (AFS Special Publication 16, 1988) and the other to decapod crustaceans (AFS Special Publication 17, 1989), have been published. A volume in press addresses the Ctenophora and Cnidaria, and two volumes in draft focus on the amphipod and isopod crustaceans.

In 1989, Dr. Kathryn A. Coates of the Royal Ontario Museum, Toronto, and Mark J. Wetzel of the Survey were selected by the Committee on Common Names of the North American Benthological Society and the AFS Committee on Names to compile the sixth volume of this series, the clitellate and aphanoneuran annelids (Acanthobdellida, Aphanoneura, Branchiobdellida, Hirudinea, and Oligochaeta). Other scientists contributing to this volume include Drs. Ralph O. Brinkhurst, Stuart R. Gelder, John W. Reynolds, and Jaqueline Madill. Although the nomenclature of the Polychaeta is being compiled by a subcommittee chaired by Dr. Kristian Fauchald, the Committee on Names has proposed that the clitellate, aphanoneuran, and polychaete lists be published in a single volume. This comprehensive publication will include the scientific and previously established vernacular names of all freshwater, marine, and terrestrial annelids occurring in the United States and Canada. Distributional information for each species will also be included.



urvey researchers sampling for aquatic Annelida in Horse Creek, Sangamon County, Illinois, in ıly 1990. At the left, Mark Wetzel uses a piston coring device to obtain a sample of the stream ıbstrata. On the right, Jeff Yockey sieves one of those samples prior to sorting and identifying the rganisms. Photos by Barbara J. Kasprowicz.

To date, over 900 species of clitellate and aphanoneuran annelids distributed among 196 genera in 25 families have been collated. The annelids will be presented in a natural or phyletic sequence of classes, orders, and families, with the genera and species within each family arranged alphabetically. Previous volumes in this series included extinct species and those listed by the U.S. Fish and Wildlife Service as endangered or threatened; however, no annelids to date are found in either of these groups. An index of common and scientific names will conclude the volume.

All aquatic and terrestrial species of annelids known to occur on the American continent north of Mexico and all marine species known to inhabit the contiguous shore waters on or above the continental shelf and occurring at a depth of 200 meters or less and within 320 kilometers of the coast are included. Coastal islands are embraced by this coverage but not the Hawaiian Islands, the Bahamas, Cuba, Bermuda, or other islands in the West Indies. Arctic coverage encompasses the USA–USSR boundary north of the Bering Strait to the west coast of Greenland, including Baffin Bay and Davis Strait and waters west of the east end of Hudson Strait, including Hudson Bay, Ungava Bay, Frobisher Bay, and Cumberland Sound. To qualify for inclusion, a species must be known to occur in the region either through authenticated published accounts or established research collections. Native as well as introduced species in the region of coverage will be included.

Unlike previous volumes in this series, common names for annelids will not be recommended. With the exception of a few leeches, aquatic annelids are unfamiliar to nonspecialists and common names for them are not in use. Common names are, however, more frequently used for terrestrial annelids, most notably the earthworms.

The AFS Committee on Names hopes that this volume will identify taxonomic groups in need of systematic revision, foster interest in surveying annelid

populations in poorly studied areas, and encourage annelid specialists to publish systematic and distributional data that they have already collected. After the volume is published, proposed changes and additions will be collected and revisions made where necessary. A second edition is proposed for release some five or ten years after the first.
Mark J. Wetzel, Center for Biogeographic Information

Publication on Plains Leopard Frog
If our native flora and fauna are to be protected, their distributions and habitat requirements must be clearly understood. Publications of the Survey traditionally provide such information for species in Illinois and surrounding areas. As a result, the flora and fauna of our state are among the best known in the world. An addition to this body of information is *Biological Notes 136*, "Distribution, Habitat, and Zoogeography of the Plains Leopard Frog (*Rana blairi*) in Illinois," by Lauren E. Brown and Michael A. Morris. Unrecognized until 1973, the plains leopard frog occurs throughout much of the great plains region of the central United States. Its distribution in Illinois includes the central portion of the state and the area bordering the Mississippi River to extreme southern Illinois. Although the species, whose habitat prior to human settlement was probably prairie, is now known from 194 localities in the state, it is not abundant at any of these localities. The relative rarity of the plains leopard frog in Illinois may be attributed to its inability to live in areas that have been converted to cropland.
Carol Johnston, Center for Biodiversity

Plains leopard frog from Spring Lake, Tazewell County, Illinois. Photograph by Douglas W. Whitman.

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December 1990 No. 302

Mayhem among Wood Ducks

Most species of ducks that nest on the prairie breeding grounds of North America achieve dispersion by establishing territories during the breeding season. Paired males that have established territories chase other members of their species from the area, and pairs without territories are forced to seek alternate nesting sites. When a shortage of wetlands occurs, many prairie ducks fail to breed because of insufficient territorial space and collect on relatively larger water areas or continue farther north to wetlands that afford little breeding opportunity but provide water and food to survive the summer.

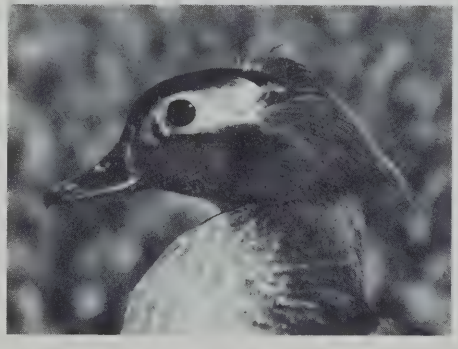
Unlike prairie ducks, wood ducks rely on a nonterritorial breeding strategy. Paired wood ducks frequently remain in close proximity to one another while feeding and resting but show no prolonged mate attachment. Woodies have, however, developed a moving "territory" of sorts, and a male will repel other wood ducks that approach within several feet of his hen, regardless of location.

Wood ducks have traditionally used riverine habitat (floodplain forests and riverflow swamps) for nesting, and the rise and fall of spring floodwaters may force pairs to seek new feeding and resting areas several times during the nesting season. Thus, the transitory nature of cover and food appears to have inhibited, at least in part, the development of a fixed-location territorial system in wood ducks. Perhaps under pristine conditions the dispersion of nest sites (tree cavities) resulted in the spread of breeding pairs throughout flooded wetland habitat, and there was no need for wood ducks to evolve a behavior to ensure territorial isolation.

Survey research changed all that in 1984 when we provided 5.3 artificial nest sites per acre (40 duplex nest boxes) at Nauvoo Slough, a 15-acre arm of the Mississippi River near Nauvoo, Illinois. The high density of nest boxes at Nauvoo Slough was in marked contrast to natural nesting conditions where suitable tree cavities occur at an average of 1 per acre and are undoubtedly more difficult to locate than highly visible boxes placed on an open marsh.

Because paired wood ducks do not exclude other members of their species from a specific wetland area, most of the wood ducks that nested on Nauvoo Slough remained throughout the day. As the breeding population increased, wood ducks frequently encountered other members of their species as they swam about looking for nest sites, food, and loafing areas. We believe that this increased level of confrontation (and aggression) between pairs may have contributed to intense defense of nest sites by incubating females.

The number of females nesting on Nauvoo Slough rapidly escalated from 46 in 1984 to 74 in 1986. In 1985, we found the first evidence that wood duck females were embroiled in conflicts at their nest sites; 3 females were found dead with head injuries. The following year 10 females were injured and 4 were killed. From 1984 through the 1990 nesting season, we found a total of 37 females with head injuries and 28 fatalities resulting from head wounds. On two occasions, we observed a female in the nest grasp the head of another female that had intruded, ostensibly to deposit an egg. Apparently head injuries were occurring when females entered nest sites already occupied by either egg-laying or incubating birds. In addition to these injuries and fatalities, over 800 eggs were crushed and 600 were removed from nest sites by competing hens during this seven-year period. A significant positive correlation was found between the number of nesting pairs in a particular year and the number of injured and dead females. Greater density resulted in higher numbers of injuries and fatalities.



Female wood duck with a head wound incurred in an attempt to enter the nest site of another female. Photo by Daniel J. Holm.

Intraspecific strife between females has drastically lowered the production of young at Nauvoo Slough. This newly observed phenomenon serves to limit production of young where local breeding populations have become too dense and is apparently unique to the wood duck. A perusal of ornithological literature provided no evidence of such intense strife among female birds. (One case involved a female tree swallow; a few others concerned males.) Thus intraspecific strife, which functions in relation to population density among female wood ducks, provides nature with another means of dampening unrealistic population growth.

Frank C. Bellrose and Daniel J. Holm, Forbes Biological Station, Center for Wildlife Ecology

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The Stoneflies of Illinois

Plecoptera, commonly known as stoneflies, are a diverse and interesting group of aquatic insects. As immatures and adults, they are associated with clean, cool running waters. Few species are collected from warmwater, organically enriched, or ephemeral streams. Eggs are laid in water and hatch within 3–4 weeks; the nymphs then undergo a gradual development (6–22 instars). Most species complete their life cycle within 24 months, although a few require 2–3 years.

As nymphs, stoneflies respond to water temperature, substrate type, and stream size, and this response is reflected in their distribution and succession along streams and rivers. As a result, a distinct micro-distribution of species and size classes is frequently observed within a particular stream reach. Microhabitats include boulder surfaces, cobble and gravel interstices, leaf packs, and accumulations of debris. The food eaten by stoneflies varies depending on species, stage of development, and time of day. Some species are shredders or predators throughout their development; others change their feeding habit as development proceeds.

Gravel riffles of Big Creek, Illinois, (top) provide the best habitat for nymphs of winter stoneflies. Log jams with leaf debris on the Little Wabash River, Illinois, (bottom) offer an excellent habitat for collecting nymphs and adults of summer stoneflies. Photos by Larry Page.

Adults are terrestrial and are collected from riparian vegetation or among rocks or debris along the shoreline. Various species emerge in a fairly fixed succession throughout the year and are designated as winter or summer stoneflies according to the season in which they emerge. Adults live about 1–4 weeks, although winter species often live longer. In many species, adults communicate by tapping on the substrate with the tips of their abdomens. This process, called drumming, enables them to find each other for mating. Although males drum throughout their lives, only virgin females respond to drumming males.

The fall and winter stoneflies of Illinois were examined in 1929 by T.H. Frison, who then undertook a faunal study of all Illinois stoneflies in 1935. At that time, Frison reported on 36 species in 17 genera. Currently, 57 species in 21 genera have been recorded from Illinois. Many of these species have highly restricted distributions and may represent threatened or endangered species in Illinois.

Efforts are currently under way to reexamine the stoneflies of Illinois, providing keys to and descriptions of the adult and immature stages and updated information on their biology. The Survey's stonefly collection will then be computerized and current nomenclature applied to all names. Species distributions will be mapped for Illinois, and gaps in our collecting patterns will thereby become apparent. Because of the restricted distributions of stoneflies and their high intolerance to pollution and environmental change, efforts will focus on collecting species initially reported by Frison. Failure to locate those species may serve as an indicator of the extent of deterioration within Illinois streams over the past 55 years. Because stoneflies are associated

vith clean running waters, collections will lso focus on streams that have been rated highly valued aquatic resource" by the)epartment of Conservation's Stream Characterization Index. The study of toneflies in Illinois should provide us vith a clearer understanding of the mportant role played by aquatic insects in treams and their place within the bio- iversity of our state.

)onald W. Webb, Center for Biodiversity

pawning Behavior in Bluegills

he bluegill, *Lepomis macrochirus* afinesque, inhabits many types of lentic nd lotic systems and is currently wide- pread throughout much of North Amer- a. This common fish, however, is one of ie most social of vertebrates, with reeding colonies containing up to 300 or iore nests. Not only are the sexes imorphic in appearance (the larger male as a bright rust-orange breast and ridescent blue cheeks; the smaller female dull blue), but they have distinct productive roles as well. The male alone responsible for constructing the nest and or providing parental care.

Contrary to much of the published terature, bluegills spawn in a variety of epths (from 1–16 feet) and on a variety of ubstrates (from bedrock to sand/gravel to ose organic silt). Spawning occurs in veral distinct breeding bouts during the ear, with the earliest commencing as ater temperatures reach 17°C (mid to te May in Illinois) and the last usually ding as water temperatures rise above)°C (mid to late July in Illinois). As one ight expect, along with this considerable mporal and spatial variation in spawning tivity comes considerable variation in productive success. Through a combina- on of field observations and experimen- l manipulations, I am currently studying ctors that influence an individual male's productive success and his decision to ovide parental care for his offspring or desert his brood in favor of continued awning.

Reproductive activity begins when eeding males aggregate into groups over otential colony site and aggressively compete for individual positions. Each male builds a nest by sweeping out a circular depression in the substrate with his caudal fin. Females arrive in schools at newly formed colonies, and nesting males display by rapidly circling their nests and taking on a much darker color. To spawn, a female enters a nest and together with the resident male swims in a circle around the nest. She dips on her side to release eggs, extruding 10–20 eggs at a time. The eggs are immediately fertilized by the male as they fall into the nest to adhere to the substrate. The female often remains in the nest only briefly, departing to spawn in other nests with other males in the colony. Thus, one female may spawn in many different nests, and one male's nest may contain eggs from a number of females.

At the cessation of spawning, the females vacate the colony, leaving the males to provide parental care. A male's parental duties consist of fanning the eggs with his fins to circulate oxygenated water in the nest and defending the site from predators, which may include snails, bullheads, minnows, and other bluegills. Development of the eggs is dependent on water temperature, but hatching usually occurs from 40 to 72 hours after fertilization. Newly hatched fry are 2–3 mm long and quite undeveloped; they require 3–7 days after hatch to become free-swimming and capable of leaving the nest.

The number of eggs received among the colonies within a single water body and among the individual nests within a single colony varies greatly. To determine factors that affect this variability, I have undertaken a long-term assessment of the reproductive success of bluegill males along a 2-km shoreline. Preliminary data reveal that males do not aggregate randomly during a season or within a lake; rather, many return to the same location to spawn in subsequent years. Nests built by larger males within the center of a colony also appear to receive more eggs than peripheral nests built by smaller males, an observation that has been made by other researchers as well.

When spawning within a colony is over, some males that received eggs do not stay to provide parental care for their brood but desert their offspring, dooming them to predation. Current theory suggests that males make the decision to stay or to desert based upon the number of offspring in the current brood versus the likelihood that future spawning efforts will result in larger broods. Many factors—the number of eggs received, the age and size of the male, the energy reserves the male has to spend, and the reduction of the brood due to predation—play a role in the decision to provide or withold parental care. Continuing investigations may help to clarify how animals make these decisions and to suggest how sexual selection and natural selection combine to shape evolutionary progress.

Julie E. Claussen, Center for Aquatic Ecology

Bluegills spawning over a nest. The female dips on her side to release the eggs, which are immediately fertilized by the male as they fall into the nest. Photo by Julie E. Claussen.

Exhibit Available for Your Hometown

At first glance, the landscape of Illinois appears to be a uniform vista of farm fields interrupted by occasional towns and cities and dissected by interstate highways. In reality, the state is a complex mosaic of habitats with a surprising variety of plants and animals. Influenced by its glacial heritage and underlying geology, Illinois is a meeting ground for organisms from widely divergent geographical areas: the eastern deciduous forest, the western great plains, the southern coastal plains, the Ozark uplift, and the northern forests. *Biodiversity in Illinois*, a traveling exhibit developed by the Survey with its two sister surveys and the support of The Nature of Illinois Foundation, illustrates the diversity of organisms found in Illinois and explains why they are here. Included are explanations of how the geology of Illinois contributed to biodiversity and how climate interacted with landforms to create distinct habitats.

Launched in October 1989, the exhibit is being shown throughout the state. At each location tours are arranged for schoolchildren and educational activities made available, including a biodiversity poster that features 64 species of plants and animals native to Illinois. The next stop for the exhibit is the Chicago Botanic Garden, Glencoe, January 5–20, 1991, and programs are now being scheduled for Glencoe schools and the general public.

If your community has a site (for example, a bank, library, or museum lobby) for the exhibit and would like to display it for at least a three-week period, call Dr. Michael Jeffords, (217) 333-5986. Information about future display sites may also be obtained.

A portion of the biodiversity exhibit on display in the lobby of the Marine Bank, Springfield, Illinois. Photo by Michael Jeffords.

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Gems of the Caterpillar World

Caterpillars generally bring to mind vormlike creatures about an inch or two ong that crawl with undulating move- nents from head to rear. We picture them n a variety of colors, often covered with hort spines. This general description uffices for many of the hundreds of aterpillar species that feed on Illinois ees. The slug caterpillars, however, do ot fit this description. The maximum ength of the largest species in Illinois is lightly more than a half inch. Slug aterpillars appear to be legless although ney possess a few tiny legs and move ver leaf surfaces in a slow, gliding notion. They also appear to be headless ecause several folds of skin cover their eads. When they are at rest, it is difficult o discern which end is the head.

Many species of slug caterpillar are nulticolored in brilliant shades of purple, ed, yellow, green, and brown. The colors robably serve as warnings to potential redators, for most species possess stiff pines that cover the surface of the upper ody and are connected to poison glands. Ve are well advised to heed this colorful arning not to touch because when the pines come in contact with our skin, they reak, releasing venom.

Pain sensations and symptoms differ onsiderably among individuals, and ariables such as the slug species in- olved, site and area of skin contact, ictim's age, and individual sensitivity etermine reactions. For most of us, the eaction is sudden intense pain that ersists for approximately 35 minutes, radually wanes, and disappears in about n hour. The affected skin area reddens ith slight swelling. The swelling may ersist for several hours and the skin scoloration for several days. In severe cases, the pain may persist for several hours with localized numbness, nausea, and even a degree of pseudoparalysis. The burning sensation may be severe enough in children or adults with very sensitive skin to require medical attention.

Although a few species are found statewide, slug caterpillars are uncommon in Illinois and some species are rare. Most species are found in the deep forests of southern Illinois, and several are limited to the deep forest environs. Trees on which they are found include black oak, sugar maple, sycamore, and redbud.

Slug caterpillars are among the more unusual caterpillars found on Illinois trees, but we occasionally come in contact with them when pruning trees or walking in brushy areas. Climbing trees also affords an opportunity for a slug caterpillar to rub against exposed skin. Fortunately these encounters are not common. If we do meet one of these creatures, we should marvel at its beauty, for slug caterpillars are truly one of the gems of the caterpillar world.

James E. Appleby, Center for Economic Entomology

The tree asp, *Eudea delphinii*, is one of the slug caterpillars of Illinois. It is shown here at about six times its actual size of slightly more than a half inch. Photo by James E. Appleby.

Calling All Hawks

Raptor populations in Illinois have declined significantly in recent decades, mainly a consequence of pesticide poisoning and the loss of foraging and nesting habitats. The Illinois Endangered Species Protection Board currently lists 12 species as endangered. Although this decline has been documented, little is known of the distribution and abundance of many raptor species in the state today. Successful protection and management of endangered raptors, however, depend at least in part on accurate population measurements.

Monitoring raptor populations is challenging because birds of prey are less common and more widely dispersed than other kinds of birds. Species that nest in forests are especially difficult to detect during field surveys because of their secretive habits and because vegetation limits the observer's ability to see birds within even relatively short distances. Because traditional census methods have inadequately detected birds of prey, more efficient methods of surveying raptors are being developed.

As part of a two-year study funded by the Illinois Department of Conservation Nongame Check-off Fund, researchers at the Survey are testing a roadside monitoring technique developed by Mark Fuller, Paul Geissler, and George Iverson of the U.S. Fish and Wildlife Service and the

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U.S. Forest Service. The technique was designed for census situations in which individual birds are indistinguishable, measurements of distance unreliable, and detection rates low. These situations are typical of many roadside counts of raptors. In addition to assessing the effectiveness of this monitoring technique, the study quantitatively describes the abundance and distribution of nesting woodland raptors in 12 study areas in Illinois.

Three 4.5-mile (7.2-km) census routes were established along county roads in each of the 12 study areas. Routes were surveyed approximately once a week from mid-April through mid-July by playing a tape recording of the call of a great horned owl at regular intervals along each transect. The owl call was used to elicit a defensive response from nesting hawks and owls and thus increase opportunities to detect them. The design of the study, however, favored the detection of diurnal hawks rather than owls.

The data analysis for this census method relies on two parameters to estimate species abundance. One, the probability of detection, estimates the chance of detecting individuals of a species at a stop that is known to be occupied by that species. The second parameter is the area occupied or the proportion of stops occupied by a species. A stop is considered "occupied" if a species engaging in normal activity is seen within the observer's detection radius. Because more than one conspecific can occupy a given stop, the second parameter is not a direct estimate of species density.

Results of the 1990 census suggested certain basic trends in the abundance and distribution of woodland raptors in the 12 study areas. Fifteen raptor species, two federally endangered and six state endangered, were observed during the study. Nine of these were detected too rarely to be included in the analysis.

Red-tailed hawks and turkey vultures were the most frequently detected species in most study areas. The red-tailed hawk, typically considered an "open country" species, had similar values for proportion of area occupied in each of the 12 study areas, regardless of percent forest cover. This pattern may indicate the fragmented nature of larger forested tracts in Illinois, especially in the Shawnee National Forest.

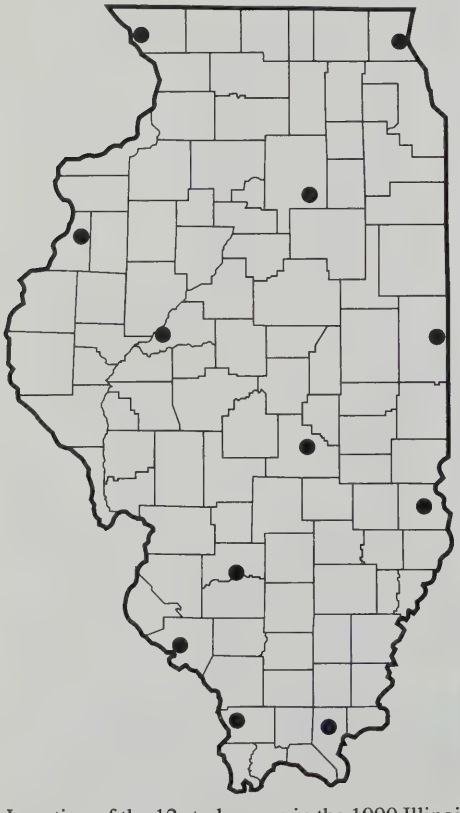
The state-endangered red-shouldered hawk, the third most frequently detected species, occupied larger proportions of the study areas in southern Illinois and in study areas that were >50% forested. Highest values were found in Clinton, Pope, and Union counties.

Although sample sizes were small, data indicated that the broad-winged hawk also had a predominantly southern distribution and was associated with study areas that were >50% forested. Cooper's and sharp-shinned hawks were uncommon in 5 and absent from 7 of the 12 study areas. Sightings of these two state-endangered species were usually isolated with no subsequent observations and could not be used in the data analysis. Data from the second year of the study may more completely describe the distribution and abundance of the broad-winged, Cooper's, and sharp-shinned hawks in Illinois.

Raptor detection rates, overall, were improved by using the call of the great horned owl. Red-shouldered hawks, broad-winged hawks, and Cooper's hawks were the most actively responsive species. The majority of vocally responsive birds flew to the forest edge to "confront" the owl recording.

Ultimately, this monitoring technique could be applied to large-scale evaluations of woodland raptor populations throughout the state. In theory, once the parameter for probability of detection by a given species has been calculated for that species in a specific habitat type, census replicates may be reduced in areas of like habitat because the existing value could be used to correct for undetected birds. The technique, however, must be tested further before it can be accepted as a quick method of monitoring raptor populations. The applicability of the technique in Illinois may become more apparent after additional data are collected.

Patti Malmborg and Glendy Vanderah, Center for Biogeographic Information



Location of the 12 study areas in the 1990 Illinois Woodland Raptor Survey. The red-shouldered hawk, an endangered species in Illinois, was the third most frequently detected raptor in the 1990 Survey. Photo by Glendy Vanderah.

ercury: Problem in Illinois Wildlife?

ccasionally Illinois citizens express ncern about the possibility of excesvely high concentrations of mercury in e fishes and wildlife of their state. High ncentrations of this element pose a reat not only to the well-being of these ecies but also to the welfare of those io may consume them. During the past years, the Survey's Analytical Chemis- Laboratory analyzed more than 5000 sue samples from 1520 fish and wildlife ecimens from various Illinois counties.

In order to determine whether levels of ercury are sufficiently high to cause ncern, we need a reference point. The S. Food and Drug Administration has set imit or action level of 500 ppb (parts per lion) of mercury in fish to be consumed the public. No federal guideline has en set for the level of mercury in meat to consumed by the public, but we can sonably assume that it would be the ne as that for fish.

The natural abundance of mercury in hes in unpolluted areas of the United States has been determined in a number of studies. Freshwater fishes analyzed during a nationwide monitoring program in 1976–1977 averaged 112 ppb of mercury, with a range of 10 to 840 ppb. A more localized study carried out in Wisconsin reported a mean of 190 ppb, with a range of 10 to 600 ppb. In each of these studies, the mean fell well below the action level set by the Food and Drug Administration, an indication that very few individual fish contained mercury at levels in excess of 500 ppb. Because a 100-fold margin of safety is built into limits set for toxic heavy metals, consumption of limited quantities of fish containing mercury concentrations in excess of the action level does not pose a major threat to health.

The mercury values (means and ranges) for the 1304 fishes analyzed at the Survey compare favorably with the published values for the natural abundance of this element in fishes from unpolluted areas of the United States. With the exception of one fish (587 ppb), all means and all ranges fell beneath the action level set by the Food and Drug Administration. Except for one deer, one raccoon, and one mink, the mercury means and ranges for the 216 mammals analyzed fell within the natural abundance ranges for fish.

Although our data do not represent a comprehensive coverage of the state, our analyses of specimens from fairly diverse counties did not reveal undue quantities of mercury. We can, therefore, reasonably conclude that this element does not pose a threat to the well-being of these species or to the welfare of the general public who may consume them.

Susanne G. Wood, Center for Wildlife Ecology

unties from which tissue samples were lyzed for the presence of mercury. Fishes in e County (northeast corner of the state) e collected from lakes within the county not from Lake Michigan.

Overwintering Strategies in Aphids

Every autumn as we prepare to minimize the effects of oncoming winter weather, insects initiate their own finely evolved survival behavior to ensure their presence next season. Insects exhibit a multitude of methods for surviving through the winter, and examples can be found in which virtually every stage (egg, larva, nymph, pupa, or adult) is the form that survives.

For aphids the standard mode of survival is overwintering eggs fastened securely to a host plant. This strategy is effected through the production in the fall of distinct sexual forms (males and oviparae) that mate and produce overwintering eggs. (Throughout the rest of the year, all aphids are unfertilized females that give birth to live young.) This method of survival is risky because the eggs are exposed to the extemes and irregularities of winter weather as well as to predators such as small birds that feed on aphid eggs. Egg dessication is a major problem, and studies show that only a small percentage of aphid eggs remain viable and hatch in the spring.

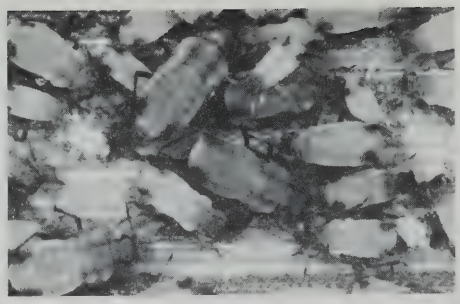
Aphids that feed on the roots of plants have evolved a method of survival that is facilitated by ants, which move the aphids to their nests far underground where they remain throughout the winter. How the aphids manage to survive for an extended period without feeding and the extent to which underground wintering occurs are not known, but the practice has been documented.

Observations over the past ten years in Illinois indicate that many aphids, in fact some of our most common pests of crops and vegetables, do not produce males and oviparae and are not maintained by ants. Most of these species are known to produce sexual forms in temperate climates; however, colonies of these aphids have been observed in Illinois every fall reproducing in the standard viviparous manner until they are killed by severe weather or die for lack of food as their host plants become dormant or die. This method would not seem to ensure the long-term survival of the species, yet every year most of these species can be found in Illinois and often in abundance. The answer to the puzzle appears to be that every growing season these tiny insects use wind patterns to migrate into Illinois and other north-central states from southern parts of the continent. Although the details are not known, each species seems to have its own pattern of migration. Primary evidence for this theory is the time of arrival. One of the earliest arrivals in Illinois is the bird cherry–oat

aphid that feeds on cereals. Winged forms arrive in central Illinois in April every year. A second species, one that is known to every farmer growing corn in Illinois, is the corn leaf aphid, which arrives by late May or early June and by midsummer can often be found in enormous colonies on corn. A third migratory pest species common in Illinois is the greenbug, a pest of grasses and cereals. Many species not considered pests also exhibit migratory behavior. Some of these do not arrive every year and others are always here. Among the latter is one of the most colorful aphid species known, the bright orange milkweed aphid.

An important question remains unanswered—do aphids actually migrate south in the fall? At present there is no evidence for a migration southward, so we assume that the annual migrants arriving in Illinois are the offspring of aphids that remained in the South throughout the year and survived the milder winters there.

David J. Voegtlin, Center for Biodiversity



An annual migrant into Illinois, the cornleaf aphid on a sorghum leaf. Photo by David J. Voegtlin.

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eregrines on the Move

alph Palmer, in his *Handbook of merican Birds*, refers to the Peregrine as hat popular and most propagandized of l raptors," dubbing it "the glamour bird." his fastest of all birds is seen on all ntinents except Antarctica, is prized for lconry now as it was by the ancients, is e mascot of the U.S. Air Force Acad-ny, and for 15 years or so has been the bject of a multimillion dollar restoration fort in North America. If a valued racing geon occasionally falls victim to a regrine, the event may seem to all but e sad owner of the pigeon to be an nor, rather like being shot down by the d Baron.

The Peregrine was never plentiful in inois, having bred at only a few cliff es along the Mississippi and Ohio ers. These and all other nesting sites in e United States were vacated by the 60s as the southern race (*Falco pere-inus anatum*) was extirpated by pesti-des. The arctic race (*F. p. tundrius*), a ring and fall migrant through Illinois, clined in numbers in the early 1970s, t recovery has been remarkable since e 1972 federal ban on most uses of DDT.

Studies of the behavior of migrating tors by Survey staff from 1973 through 89 included observations of seven ung arctic Peregrine Falcons tracked ough Illinois by means of a dime-sized dio transmitter glued to a tail feather. apped in late September or early tober at banding stations in Wisconsin out 100 miles north of Chicago, these ds had hatched about three months viously in the Canadian arctic. They d been hunting on their own for barely a nth and were now making their first p south to spend the winter in Central or uth America.

A typical day included about 17 hours on a perch, 6 hours of migratory flight, and 1 hour of hunting flight. On days when these young Peregrines did not migrate, perch loafing increased to 23 hours. Invariably they chose high bare branches for perching, usually in defoliated trees. Achieving solitude was seldom easy, however, for within a short time of the Peregrine's arrival, a number of resident birds would perch nearby, sounding alarm calls and occasionally making mock attacks on the bored-looking Peregrine. Squirrels sometimes joined in the fray. If the Peregrine was patient, and it usually was, the antagonists would gradually quiet down or go away, apparently satisfied that the big falcon was intent on a snooze and not a meal.

Migration took place on about six of every seven days, generally from mid-morning to late afternoon and for durations varying from 1 to 9 hours but usually about 6 hours. Most migratory flight was by virtually effortless soaring and gliding. In this type of flight, hawks gain altitude by gliding in circles in rising bubbles of warm air (thermals) created over ground heated by the sun. After the warm air dissipates, usually at altitudes of a thousand or more feet, the hawks glide in the migratory direction until they encounter another bubble of rising air. The longest and fastest migratory flight was that of a female on October 2, 1989. After spending the night near Cicero Avenue and 115th Street in Chicago, she flew 360 miles to Dover, Tennessee, at a speed of 40 miles per hour. The average for the seven birds, including one followed to Mexico and one to Florida, was a more modest 120 miles per day at 21 miles per hour. Weather controlled migration; fair weather and north winds resulted in the longest flights while thick overcast with rain inhibited migration.

A three-month old Peregrine Falcon netted 20 miles north of Milwaukee, Wisconsin. Its only stops in Illinois were at midday, when it hunted in the Rosehill and Bohemian National cemeteries in Chicago before continuing migration. It crossed into Indiana about 50 miles south of Chicago. Photo by Aat In't Veld.

About an hour a day was spent in hunting flight. The falcon's most famous hunting tactic is to dive on prey from high above, and it is in diving that the Peregrine has earned its reputation as the fastest bird, with reports of dives in excess of 200 miles per hour. However, none of the seven young birds we observed hunted in this way. Instead, they flew at 20 to 30 miles per hour along the edges and over the tops of woodlots and cornfields, appearing suddenly over adjacent clearings where ground-foraging birds were likely to be found. Under these circumstances, surprise, height, and speed favored the Peregrine. The abundant riverine habitat, the patches of fragmented forest, and the variously harvested cornfields in Illinois are ideal for this type of hunting.

Migration is thought to be a strenuous and perilous time for birds; however, the

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seven Peregrines we observed appeared to be making leisurely trips through a land of plenty. Yet other studies indicate that only one of the seven will survive to breed at age three; the majority will have fallen victim to guns, Great Horned Owls (*Bubo virginianus*), disease, or other calamities during migration or on their wintering grounds.

William W. Cochran, Center for Wildlife Ecology

Buffer Strips and Nonpoint Pollution

Streams, lakes, and groundwater can be contaminated by either point or nonpoint sources of pollution. Point source pollutants enter waters from specific, readily identifiable sources such as effluent pipes or sewage outfalls. Pollutants from nonpoint sources enter water less directly, across the surface of the soil in sheet flow or below ground through subsurface movement. The source of nonpoint pollution is not readily identified because of its diffuse nature, for example, the movement of fertilizers from urban and agricultural areas into lakes and streams. During the past 20 years, pollution control has generally been directed at reducing the quantity and toxicity of point source discharges. Although this effort has improved water quality, researchers now recognize that further improvement must focus on reducing nonpoint sources.

In Illinois and other midwestern farming states, agricultural practices appear to be the principal cause of nonpoint pollution. Under conventional practices, much of the nitrogen fertilizer is quickly flushed from the surface soil to the subsurface water, eventually entering streams and lakes in the form of nitrate. If, for example, 140 pounds of nitrogen fertilizer are added to an acre of cropland, approximately 90 pounds are incorporated into the crop plants and 50 pounds are lost in surface and subsurface runoff. Nitrate, whether applied directly to the soil or formed through the nitrification of ammonium applied to the soil, rapidly leaches to subsurface and deeper groundwater. In fact, 99% of the nitrate movement from agricultural fields is through subsurface leaching; only 1% is attributed to surface runoff. Federal legislation, for example, the Food Security Act, now mandates the control of nonpoint pollution on farmlands.

High levels of nitrate in surface waters cause blooms of bluegreen algae that deplete oxygen in surface waters at night or during their decomposition. The oxygen depletion that results can kill aquatic organisms, including sport fish. Waters high in nitrate stimulate the growth of aquatic macrophytes, thereby making streams and lakes less desirable recreation sites. Nitrate in drinking water also causes methemoglobinemia (blue baby syndrome), which may be fatal in infants. To prevent infant fatalities, the U.S. Environmental Protection Agency has set a nitrate level of 10 parts per million (ppm) for drinking water. Levels near 10 ppm are commonly found in local reservoirs such as Lake Vermilion. Finally, nitrate has been implicated in the formation of nitrosamines, carcinogens that may affect many animal species.

Unlike the localized and highly technical sewage and water treatment facilities associated with the control of point source pollution, the reduction of nonpoint source pollutants requires a detailed understanding of the broader landscape along with the recognition that control procedures must be economically attainable as well as scientifically sound. Recent efforts in the agricultural watersheds of the Atlantic Coastal Plain indicate that reduced nonpoint source inputs and the improved stream quality that results can be attained through the use of streamside vegetative buffer strips. We hypothesized that riparian forest and perennial set-aside vegetation would also reduce the subsurface transport of inorganic nitrogen to surface waters in agricultural watersheds of the Midwest. Our study is one of the first conducted in central Illinois to determine specific functional processes that control nutrient transport in agricultural areas where streams are bordered by forests or perennial grasses.

Typical application of anhydrous ammonia to an Illinois corn crop. For every 140 pounds of nitrogen fertilizer added to an acre of Illinois cropland, approximately 50 pounds are lost in surface and subsurface runoff. Photo by Bruce C. Dickson.

Following a two-year investigation funded by the Illinois Water Resources Center, we have found that streamside buffer strips effectively reduce subsurface inputs of nitrate to streams. Peak concentrations of nitrates in subsurface water on crop sites without buffer strips reached 40 ppm; however, concentrations of nitrates in subsurface water from adjacent areas with perennial grass and forest buffer strips reached peak concentrations of only 8 and 4 ppm, respectively. Our results indicate that nitrate concentrations in subsurface water would be reduced by 80% after passing through a grass buffer strip and by 90% after passing through a forest buffer strip.

Buffer strips appear to be an effective and economically feasible means for reducing the nonpoint subsurface movement of nitrates to surface waters in agricultural areas of Illinois and other midwestern states. Further research is underway at the Survey to determine the minimum width of buffer strips and the time needed to establish them. Our ultimate goal is to provide farmers with buffer strip prescriptions that will enable them to reduce nonpoint nitrate pollution.

David A. Kovacic, Department of Landscape Architecture, University of Illinois, and Center for Aquatic Ecology; and Lewis L. Osborne and Bruce C. Dickson, Center for Aquatic Ecology

Long-term Use of Soil Insecticides

Long before the concept of sustainable agriculture captured the attention of policy makers, extension entomologists in Illinois had recommended that farmers rotate corn and beans as a way of controlling feeding damage by the corn rootworm. This practice eschews insecticides and qualifies as preventive pest management. Despite the economic and environmental benefits of rotation, several million acres of corn in Illinois are grown annually as continuous monocultures, a practice that increases the probability of corn rootworm infestations and damage. Because the population levels at which the corn rootworm does economic injury are not well established, a soil insecticide is recommended when corn is planted in successive seasons. With few reliable corn rootworm insecticides on the market, the same product tends to be used year after year. The result can be a phenomenon known as enhanced biodegradation, wherein soil microorganisms that have become adapted to the insecticide break it down so quickly that feeding damage by corn rootworms is not prevented.

Because the chemical control of corn rootworms will remain the predominant management strategy in continuous cornfields over the next decade, management practices for the long-term use of the registered products that are available must be developed. In response to that need, Dr. Allan Felsot of the Survey's Center for Economic Entomology reviewed the management techniques currently available and those recently proposed for coping with the adverse effects of enhanced biodegradation. He divides those techniques into two categories—operational and technological. Operational techniques are based on biological principles whereas technological techniques require alterations in formulation chemistry or structural chemistry of the insecticide. The operational alternatives include conservation of pesticides (for example, scouting to determine when the application of insecticide is warranted), crop rotation, careful calibration of application equipment, precise timing of applications (for example, at the time of cultivation when larvae are actively feeding), and the use of a pesticide only every other year or at even longer intervals. Among the technological alternatives are extenders and inhibitors that delay biodegradation, new formulations (for example, controlled release), and directed chemistry (development of new soil insecticides possessing high toxicity to specific pests but low toxicity to other organisms). Although new insecticides and formulations are slowly being developed, operational techniques have the advantage of being relatively inexpensive and readily implemented.

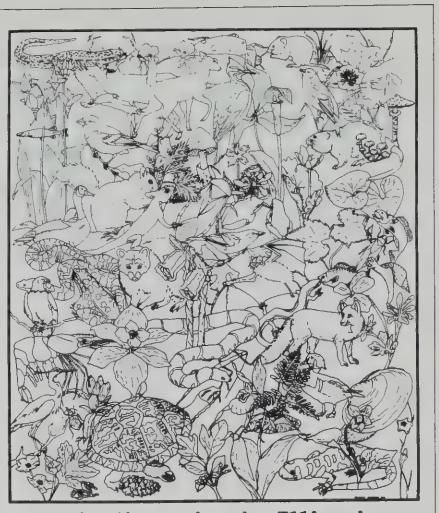
One operational technique, the rotation of chemicals of different chemistry, has been suggested as a way of allaying the development of insect resistance, but its usefulness in preventing enhanced biodegradation of soil insecticides has not been extensively studied. During 1985–1990, Dr. Felsot studied the effectiveness of this strategy in a two-acre experimental field at the University of Illinois Northwest Illinois Agricultural Research and Demonstration Center near Monmouth. In a replicated, randomized block design, multi-year, single year, and rotational use of the insecticides carbofuran, fonofos, and terbufos were established over a six-year period. Analysis of the data has shown that the rotation of fonofos with either carbofuran or terbufos slowed the development of enhanced biodegradation and improved the control of corn rootworms. Terbufos did not cause enhanced biodegradation in soil; however, one of its toxic breakdown products degraded faster after repeated use of terbufos than it did after a single application. Rotation of carbofuran with the other two insecticides had no effect on the persistence or efficacy of carbofuran. Dr. Felsot concluded that the annual rotation of chemicals may be useful in maintaining the long-term efficacy of the soil insecticides used to control corn rootworms.

Allan Felsot, Center for Economic Entomology

Donald E. Kuhlman of the Cooperative Extension Service at the University of Illinois at Urbana-Champaign examines root damage caused by the feeding of corn rootworm larvae. Lodging has occurred and the plants have fallen because the support roots have been severely damaged or lost. Photo courtesy of Agricultural Entomology Extension, University of Illinois.

Biodiversity Poster Available

A 17"×22" poster suitable for coloring is now available from the Survey. More than 60 plants and animals native to Illinois are pictured. The poster is appropriate for elementary and junior high school science classes and such other ecology-oriented groups as 4-H clubs and Scouts. Educators can design a number of activities around the poster, including identifying the organisms and grouping those that are closely related (taxonomy), categorizing those that are aquatic versus those that are terrestrial (habitat preference), or merely acquainting students with the astonishing diversity of plants and animals that live in our state. The hunt-and-find format is appealing to younger children who may lack the motor skills to color the poster but will enjoy finding and naming the animals. Individual posters are available for 15 cents; classroom sets of 30 (with an answer key) may be purchased for $3.50. To obtain copies, send a check or money order to the Distribution Center, Illinois Natural History Survey, 607 East Peabody Drive, Champaign, Illinois 61820.



Biodiversity in Illinois

Securing the Future

Calendar year 1990 was productive and satisfying for the Survey. One event, however, was extremely significant although its origin was many years previous. On August 23, 1989, Mr. William F. Nichols, a prominent businessman from Madison County and a longtime friend of the Survey, passed away. He was a hunter and an avid conservationist with such a keen interest in wetlands and their associated wildlife that he often attended professional scientific meetings. This interest translated into the ownership of a private marsh at Horseshoe Lake, where he hunted, protected a heronry, and welcomed throngs of bird watchers. A warm friendship and genuine respect developed between Bill and Survey researchers. Bill's respect for the staff took the form of a bequest to help assure long-term research efforts at the Waterfowl Research Laboratory of the Forbes Biological Station. We are most grateful to him for his unselfish gesture and we will strive to maintain the high standards that he so appreciated.

If you are interested in financially supporting sustained research in plant and animal resources, I would welcome the occasion to discuss your interests, our needs, and various gift opportunities, including bequests.

Lorin I. Nevling, Chief, Illinois Natural History Survey

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REPORTS

March 1991 No. 305

Key Players in Aquatic Systems

Aquatic plants, large and small, are the primary producers in lakes, ponds, and rivers. They assimilate energy from the sun and use carbon dioxide in the process called photosynthesis. As they photosynthesize, they produce oxygen, sustain their bodily functions, and grow. This very basic metabolic process makes them a vital part of aquatic systems because the oxygen they produce is essential to other life in the water.

Aquatic plants also provide food and habitat for organisms living in the water and for terrestrial organisms that use aquatic resources. Many invertebrates, including mayflys and midges, rely on vascular aquatic plants and their attached algae (periphyton) for food. Some invertebrates use the leaves and stems of aquatic plants as substrate for building their homes (cases). In turn, invertebrate fauna that reside on aquatic vegetation are a preferred food of some fishes—for example, bluegill and young largemouth bass—and many species of fry find protection from predators in stands of vegetation. Waterfowl also feed on the leaves of aquatic plants and some, like the diving duck, feed on the nutritious tubers and turions (overwintering buds). The canvasback (*Aythya vallisneria*) prefers turions produced by wild celery (*Vallisneria americana*) during its migration along the Mississippi Flyway. Waterfowl also rely on aquatic vegetation for brood habitat.

In addition to serving as a food and habitat resource, aquatic plants affect the quality of water. Large (macrophytic), rooted vascular plants break the force of waves generated by boat traffic and wind and help to stabilize sediments, ultimately reducing the level of suspended solids. Aquatic vegetation rooted along shorelines reduces soil erosion, thereby slowing the eutrophication (aging process) of lakes and ponds and enhancing populations of bottom-dwelling and bottom-feeding organisms.

Sediments enter ponds, lakes, and rivers continually and with those sediments come nutrients. When the inflow of sediments and nutrients is excessive, eutrophication accelerates along with a number of other negative changes. When nutrients are plentiful and other environmental conditions favorable, plant populations grow abundantly. Early in the growing season algae (small non-rooted plants) may use the excess nutrients before rooted vascular plants initiate growth. The result is an algal "bloom" that can reduce the penetration of light sufficiently to limit or even prevent the growth of submersed macrophytes, thereby upsetting the balance between plant populations. Surface algal blooms can also cause oxygen deficiencies in the water below by blocking the passage of gases at the water's surface and by preventing the growth of oxygen-releasing submersed plants. If submersed plants have the opportunity to take advantage of excess nutrients, however, they quickly and easily develop abundant populations. Consequently, lakes and ponds with an overabundance of algae may also have an overabundance of macrophytes.

Adequate light levels are necessary for plants to photosynthesize; however, increased sediment loads reduce water

Populations of aquatic plants can become prolific, especially when nutrients are abundant and other environmental conditions are conducive to plant growth. The photo on the left was taken at Pool 19 near Keokuk on the Mississippi River; the vegetation is American lotus (*Nelumbo lutea*). Without vegetation, shoreline erosion can become a severe problem, as shown in the photo on the right taken at Newton Lake. Photos by Pamela P. Tazik.

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clarity and light penetration and create conditions unfavorable for the growth of aquatic vegetation, particularly submersed plants. If the vegetation fails to survive and grow, sediment loads increase even further. Excessive sedimentation also affects spawning, reduces the fitness of fishes by encouraging certain diseases, and interferes with the feeding behavior of those that rely on sight to find food.

Plants play a vital role in maintaining the health and quality of aquatic systems. When vegetation is scarce or absent, an entire trophic level (primary producers) is missing and the biological integrity of the system is disrupted. The biotic components (e.g., herbivorous organisms) as well as the abiotic components (e.g., water clarity) of an aquatic system affect plant populations. In turn, plant populations affect both of these components. On the biotic level, for example, periphyton levels and invertebrate populations are affected by changes in aquatic vegetation; on the biotic level, oxygen levels and sediment loads are altered. The balance between aquatic vegetation and the surrounding ecosystem is delicate but crucial to the operation of the system, and either overabundance or paucity of vegetation jeopardizes the system.
Pamela P. Tazik, Center for Aquatic Ecology

Falcons Funnel through Chicago

Various daily activities of young Peregrine falcons (*Falco peregrinus*) migrating south for the winter were discussed in last month's *Survey Reports*. Three of these birds were radiotracked along Lake Michigan and through Chicago, thereby offering an opportunity to test the 1929 proposition of Geyr, a German ornithologist who suggested that migrating birds may follow *lietlinie* or leading lines. A definition of the term appeared in the *Wilson Bulletin* (March 1977, page 51): "Leading lines are topographical features, usually long and narrow, with characteristics that induce migrating birds to follow them. The birds are influenced by these lines in choosing their direction of flight, being so to speak, led by them."

One such topographic feature is the Lake Michigan shoreline. None of the falcons was observed to follow the lakeshore closely, as one would when walking the beach or sailing a small boat. Instead, the three birds flew nearly straight courses that approximately paralleled the meandering shoreline until they reached Lake Forest, where the lakeshore begins curving east.

Streets and highways may also act as leading lines. From Highland Park to Wilmette, a corridor formed by the environs of U.S. Route 41 and the Edens Expressway is visible on Landsat photographs as a narrow 12-mile-long gouge in the vegetation running south southeast. At Highland Park, the birds turned south southeast along Route 41 and the Edens Expressway.

From Skokie and Evanston for about 20 miles through Chicago to its southern suburbs is the vast network of Chicago streets, an essentially north-south, east-west grid of streets and buildings. The birds flew straight south through Chicag one along Cicero Avenue, one along Pulaski Road, and the third between Ashland Avenue and Halstead Street, all to the west of the Loop and its tall buildings.

Did the lakeshore, Edens Expressway and Chicago streets act as leading lines o was it by chance that the courses of the three birds paralleled these landscape features? The normal courses flown by t birds for hundreds of miles south of Chicago are shown in the table below. These courses differed from each other and from the alleged leading lines, a finding which suggests that their routes through Chicago were a matter of choice not chance.

One other Peregrine was lost in Chicago, flying a course identical to that of the 1989 female shown in the table. It stopped to hunt along the Calumet Sag Channel near Cicero Avenue in Alsip, where signals from both transmitters (on on a tail feather and one on a leg band) abruptly quit. Simultaneous electronic failure of both transmitters is unlikely; it more probable that the bird fell in the water after being shot or was birdnapped and placed inside an automobile, either o which would stop signal transmission.

Three Merlins (*Falco columbarius*), a falcon somewhat smaller than a Peregrine and much like it in looks and habits were tracked into Chicago on courses ve similar to those of the Peregrines. Two were followed to southern Illinois, but one, like the Peregrine above, disappeare along the Calumet Sag Channel in Alsip.

Courses flown by three Peregrine falcons and two Merlins on various portions of their migratory routes, and the directions of topography along th portions. Due south is indicated by 180°.

		Peregrines			Merlins	
Portion of route	Direction of topography	1975 female	1989 male	1989 female	1972 female	1974 male
Sheyboygan, Wisconsin, to Lake Forest, Illinois	180° average lakeshore	180°	180°	180°	180°	180°
Highland Park to Wilmette	152° Edens Expressway	152°	152°	152°	152°	152°
Skokie to South Chicago	180° streets	180° Pulaski Road	180° Halstead Street	180° Cicero Avenue	180° Harlem Avenue	180° Cicero Avenue
South Chicago to end of tracking	variable or none	162° Florida	158° Kentucky	183° Tennessee	190° Southern Illinois	178° Southern Illino

Boundaries of the migratory routes observed from the Illinois–Wisconsin border to south of Chicago for four Peregrine falcons (right) and three Merlins (left).

The tracking vehicle used in 1989. Directional antennas are attached to a pipe that passes through a hole in the roof and can be rotated from inside the vehicle. Flying radio-tagged birds can be heard at distances as great as 40 miles. When perched, radio-tagged Peregrines can be heard at a distance of about 5 miles. Here tracker Aat In't Veld monitors a Peregrine perched a few miles up the Lake Michigan shore. Photo by William W. Cochran.

The funneling effect of the west shore of Lake Michigan on south- to southeast-bound fall migrant falcons should result in increasing numbers of falcons south from Manitowoc, Wisconsin, to Lake Forest, Illinois, and perhaps about ten times as many Peregrines would pass along a Chicago corridor between Halstead Sreet and Cicero Avenue as through any other 5-mile-wide path in the state. Concentrations along Edens Expressway in Highland Park, Northbrook, and Northfield would probably be higher yet. Thus, Lake and Cook counties are apt to contain some of the best falcon watching spots in the Midwest. Peak numbers of migrant Peregrines occur from the last few days of September through the first week of October; Merlins are most abundant from mid-September to mid-October.

William W. Cochran, Center for Wildlife Ecology

INHS Network: The Tie That Binds

Computers are of growing importance in the workday of Survey scientists and support staff. As increased amounts of data are stored on computers, the ability to exchange and share information electronically becomes essential. Data can, of course, be printed out and sent off or exchanged via floppy disks, but these methods are inefficient. The data may be too extensive to fit on a floppy disk, or the sender's and recipient's computers may be unable to read each other's disks. Hard copies have their own storage problems and are of little value if the recipient wants to do further computer analysis. The most direct way of exchanging electronic information is to connect computers through a network, and the Survey is now in the process of installing such a network.

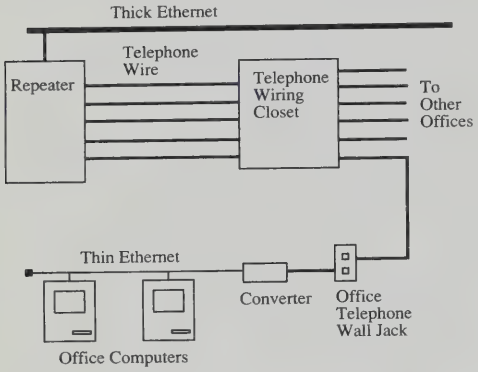
The Champaign staff are housed in two areas on the campus of the University of Illinois: the Natural Resources Building and a cluster of buildings referred to as the Natural Resource Studies Annex. The network will not only connect computers within each site but will also connect the two sites. In addition, personnel at the field stations scattered throughout the state will be able to use the network by dialing in over phone lines. The Survey's network will be connected to the University's network, which in turn is connected to the worldwide Internet. When the Survey's network is in place, staff will be able to reach out to computer systems throughout its own buildings and to those at sites throughout the state, the country, and the world.

The network has gone through the design phase and is now being installed. One long, thick piece of network cabling (the thick ethernet) runs the length of the Natural Resources Building and acts as the backbone that joins all connections. Scattered along the ethernet are network boxes called repeaters. Existing telephone wires carry the network from the repeaters to each office or lab. Within offices, a thinner cable (the thin ethernet) connects each computer. A signal converter handles the transition between the telephone wiring and the thin ethernet. By using repeaters to branch off from the ethernet to individual offices, we have built a star configuration as shown on the following page. All offices are interconnected, but if a problem develops in one office, that cable can be partitioned off without disturbing the functioning of the network.

Thin ethernet cable will be laid throughout each building in the Annex; however, all buildings must be connected so that the complex can act as a single unit. To accomplish this, fiber optic cable will be pulled between buildings to carry network signals and tie buildings together. This cable is capable of high transmission speeds and also prevents ground-striking lightning bolts from damaging equipment.

What will these networks do for the Survey? A big benefit will be the ability to share information between computers. When an employee needs a copy of a file, it can be transferred over the network, and such transfers can take place within a building, across campus, or across the state. A team of scientists can work on the same document, keeping each other updated instantly on changes without worrying about computer compatibility or accumulating endless reiterations of paper copies.

An additional benefit is electronic mail (E-mail), a method of communicating among people on the network. E-mail allows employees to avoid telephone tag and interruptions to their work because messages are sent at the convenience of the sender and read at the convenience of the recipient. Groups of people can be reached as easily as a single person, and a message can be sent with a return receipt, notifying the sender when the recipient has read the message.



The star configuration used to create the Survey's network is shown here. Each repeater can be thought of as the center of a star. The wires running from a repeater to various offices and labs form the rays of the star.

Centralized backups are also much easier over a network, and valuable data can be kept safe without the tedium of using floppy disks or the expense of multiple tape units. Programs that handle scheduling can be used over a network to coordinate meetings, room assignments, and the use of vehicles or other equipment. The connection to the network of the University of Illinois will open the door to computer systems on campus and at other Internet sites. The ways in which this network will be used will be as varied as the people using it.

Sue Klefstad, Center for Biogeographic Information

Attention Nature Photographers!

The Survey will sponsor a workshop this spring for those interested in learning more about nature and how to photograph it. The first session is Thursday evening, April 11, in the Natural Resources Building on the campus of the University of Illinois at Urbana-Champaign. Michael Jeffords, entomologist and educational liaison with the Survey and staff photographer for *The Nature of Illinois* magazine, and Susan Post, research biologist at the Survey, will discuss nature photography and aspects of the natural history of central Illinois woodlands. The field portion of the workshop will take place in Champaign and Piatt counties, including Trelease and Brownfield woods and Allerton and Lodge parks, on Saturday, April 13. A critique of photographs taken will be held Tuesday, April 23, in the Natural Resources Building. The cost of the workshop is $15. For details and registration materials, contact Michael Jeffords at the Survey, 217-333-5986.

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ew Residents on Sanctuaries

anctuaries in Jasper and Marion counties ave served the endangered prairie-nicken (*Tympanuchus cupido*) well for ome twenty years. Densities of these rds and their nests were the highest nown in the range of the species. In sper County, however, ring-necked easants (*Phasianus colchicus*) also sponded dramatically and contributed in rt to the decline of the prairie-chicken opulation, especially in the 1980s. Long-rm declines (1963–1990) in fertility and tch rate of prairie-chicken eggs gradu-ly became evident and may represent the assic symptoms of inbreeding depres-on. Pheasant control by the Illinois epartment of Conservation has been ccessful on the sanctuaries, but like the eservation of other endangered species human-altered environments, the pres-vation of prairie-chickens, numbering out 75 birds in the spring of 1990, may w hinge on various forms of genetic anagement.

Other grassland-dependent species ve responded to sanctuaries, too, cluding an abundance of prairie voles *licrotus ochrogaster*) and southern bog mmings (*Synaptomys cooperi*), both ainstays in the diets of short-eared owls *sio flammeus*) and Northern harriers *ircus cyaneus*). This combination of od and grassy roosting cover has long racted these two endangered raptors to sanctuaries in winter. Short-ears ually disappeared from the areas in rch and harriers by mid-April. In 1990, wever, both species stayed to breed in od numbers.

The 1990 breeding phenomenon, dent on both sanctuary systems, was first instance in 28 years of nest studies in which short-eared owls were verified as breeders. Thirteen nests were found, and flightless but growing owlets were observed widely scattered around their nest sites in sanctuary meadows. The first harrier nest was found in 1983, another occurred in 1989, and eight were located in 1990. All told, seven short-ear nests and three harrier nests fledged young in 1990.

The upland sandpiper (*Bartramia longicauda*), a fourth endangered species, typically breeds on about half of the 14 scattered sanctuaries in the two counties. Two threatened species, the loggerhead shrike (*Lanius ludovicianus*) and Henslow's sparrow (*Passerherbulus henslowii*), are occasionally seen. In 1990, two successful nests by king rails (*Rallus elegans*) provided another first in the data base for breeding birds in sanctuary grasslands. King rails are believed to be declining in numbers and may be listed as threatened or endangered in the near future. Other sanctuary vertebrates include the common hunted species, passerine birds, reptiles, and box turtles that make good use of relatively undisturbed grasslands.

For the first time in 28 years of nest studies, the short-eared owl was observed to breed on the prairie-chicken sanctuaries in Jasper and Marion counties. This young short-ear was photographed on the Yeatter Sanctuary by Ronald L. Westemeier.

Sanctuary vegetation is predominantly—but not entirely—introduced cool-season grasses and forbs or seeded stands of warm-season prairie grasses. One 40-acre tract, known locally as the Walter's 40, recolonized naturally with some 60 species of prairie plants representing 19 families, all of which are local ecotypes. The Walter's tract was purchased by The Nature Conservancy in 1973 and added to the sanctuaries. Since then, regular prescribed burning and the removal of trees and brush gradually opened and transformed the area. A profusion of color can be seen there each summer and fall, and seed harvests from the site now contribute to restorations on other sanctuaries.

The prairie-chicken persists, admittedly on the brink of extinction, as the focal species of the sanctuaries, but this project should be seen in a broader context: the restoration of the grassland ecosystem. Results from the two sanctuary systems have been broadly consistent with preserving the full array of biological diversity in Illinois. Not only do four endangered species and several threatened or increasingly uncommon species benefit, but the hunted species, other fauna, and native prairie plants are much a part of annual research and management programs. Any additions to the sanctuary areas can be expected to further these objectives.

Ronald L. Westemeier, Center for Wildlife Ecology

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Flatwoods in the Flatlands

The Illinoian tillplain south of the Shelbyville Moraine is a landscape of subtle beauty. Hidden away in this region between Shelbyville and the Shawnee Hills are outstanding old-growth and old-second-growth remnant post oak flatwoods. Primarily restricted to the Illinoian till plain of Illinois and Indiana, these post oak flats were once widespread in the region. By the mid-1970s, however, only 26 stands totaling about 634 acres (just under one square mile) of relatively undisturbed southern flatwoods remained in Illinois, and some of these sites have since been lost.

With funding from the Illinois Department of Transportation and the Department of Conservation's nongame check-off fund, Survey botanists have begun a study of selected post oak flatwoods. Fieldwork has been completed at six of eight sites. The vegetation and soils data collected will help to quantify interrelationships between edaphic factors (texture, fertility, and organic matter content of the soil) and forest structure, including number and density of herbaceous species.

Post oak flatwoods are characterized by poorly drained and slowly permeable soils with an abrubt increase in clay content in a subsurface soil horizon that restricts the movement of water and roots. Because of slow permeability, soils remain saturated in the spring. After the surface moisture has evapotranspired during the summer months, however, subsurface moisture is largely prevented from restoring moisture to the primary rooting zones. For this reason, species of drier glade and barrens habitats occur in many flatwoods along with lowland forest species.

In southern Illinois, both post oak flats and barrens (savannalike openings within an upland forested landscape) are characterized by open-grown post, blackjack, and black oaks and by Texas, shagbark, and pignut hickories. Post oak flatwoods, however, also support occasional lowland oaks such as pin, shingle, overcup, and swamp white oak, although these are sometimes restricted to local depressions. The understory of post oak flatwoods includes a mixture of upland forest herbaceous species, including several sedges (*Carex* spp.), with lowland graminoids such as stout wood reed (*Cinna arundinacea*), sedges (*Carex* spp.), and spike rush (*Eleocharis verrucosa*). One site had openings with a ground cover of *Sphagnum* sp., a moss, together with prairie blazing star (*Liatris pycnostachya*), spike rush, and quillwort (*Isoetes melanopoda*), an uncommon vascular cryptogam sometimes found in seeps on glades. Barrens, in contrast, usually support a greater complement of prairie grasses and lack the lowland species. Many barrens are dwindling in size because of the colonization by woody plants in openings during the past several decades.

Data from Survey studies of barrens and flatwoods indicate that the numbers of species in these communties ultimately decrease as woody plants invade. Analyses of size-class distributions suggest that the density of woody plants has increased in many of these stands during the past century. These data suggest that an ecological force now largely missing from the landscape once maintained more open conditions in these communities. That ecological force was fire.

Though the understanding of the ecology of post oak flatwoods is incomplete, preliminary analyses of our data reveal several insights that may prove useful to natural resource managers. Although some stands retain a relatively open aspect with a poorly developed shr layer, others (apparently on soils with slightly better drainage) show evidence c vegetational change characterized by the development of a subcanopy and shrub stratum. Suprisingly, under both conditions, we often found a sparse herbaceou understory with limited diversity. At five unburned sites in our study, the density o herbaceous species ranged from 1.6 to 2. species per $^1/_4$-meter-square plot. Total species richness in the herbaceous stratu at these sites ranged from 41 to 63 specie bare ground ranged from 66 to 82%. In contrast, at a site that had been managed with annual fires over the past fifteen years, 85 herbaceous species were identified and bare ground measured onl 31%. The increase in species richness an density was in native taxa appropriate to the habitat. Perhaps a more accurate way of stating this outcome would be to note that the unburned sites have undergone a decrease in richness and density of nativ herbaceous species over several fire-free decades.

Survey botanist Rick Phillippe stands near an opening in Chip-o-Will Flatwoods, a registered Illinois Natural Heritage Landmark in Washington County. Photo by John B. Taft.

Buffalo clover (*Trifolium reflexum*), an endangered species in Illinois, was recently found in two of the state's post oak flatwoods. Photo by John B. Taft.

At least one plant species listed as endangered in Illinois, the buffalo clover (*Trifolium reflexum*), is now known from post oak flatwoods. Before our survey, this rare native clover was thought to have been reduced in Illinois to a single population in an Adams County barrens. Of specific interest is the apparent preference of the buffalo clover for sites that are periodically mowed, such as the lawns of cabins in flatwoods remnants. Mowing, in this case, may mimic the role of fire in the forest community.
John B. Taft, Center for Biogeographic Information

Extension Entomology at the Survey

A primary mission of extension entomologists in Illinois is to make research-based information available to the citizens of the state, a mission shared by the Cooperative Extension Service and the Survey. Although the extension entomology group is administered through the College of Agriculture on the Urbana-Champaign campus of the University of Illinois, we are located in the Center for Economic Entomology at the Survey. This mutually beneficial arrangement fosters frequent and valuable interactions between entomologists and other research scientists at the Survey. At the same time, our liaisons with county extension advisers allow us to bring local and regional concerns to the attention of Survey researchers.

Five scientists, each responsible for a particular area of expertise, make up the extension entomology group: Michael Gray (field and forage crops), Phil Nixon (households and ornamentals), Roscoe Randell (vegetable and fruit crops, turfgrass, and ornamentals), Kevin Steffey (field and forage crops and youth programs), and Rick Weinzierl (livestock and stored grain).

Extension entomologists provide information and educational programs on insect management to farmers, homeowners, county extension advisers, professional consultants, pesticide dealers and applicators, chemical and seed company representatives, pest control operators, and many others. To deliver this information, we rely on radio and television, newspapers and magazines, and timely newsletters. We coordinate the production of two of the College of Agriculture's most widely read newsletters, the *Pest Management & Crop Development Bulletin* and the *Home, Yard, & Garden Pest Newsletter*. These two publications are mailed weekly throughout the spring and summer to more than 4,000 subscribers in Illinois and neighboring states.

In addition to participating in local meetings and seasonal field days, the entomology group conducts educational workshops and short courses, in-service education programs for county advisers, and training and certification clinics for commercial and private pesticide applicators. We also provide leadership for two multidisciplinary pest management programs held annually in Illinois. The Illinois Agricultural Pesticides Conference, which has been held in January every year since 1949, attracts about 1,000 participants and emphasizes the use of pesticides within an integrated crop management system. At the Illinois Crop Protection Workshop, held for the seventeenth consecutive year in March of 1991, extension and research specialists provide training for about 300 people who attend issues-oriented general sessions and specialized sessions that emphasize pest problem diagnosis and integrated pest management.

Extension entomologists author five pest management guides each year, and these are included with similar publications from agricultural engineering, agronomy, horticulture, and plant pathology in the annual *Illinois Pest Control Handbook*. Recently, Rick Weinzierl directed the development of a series of publications on nonchemical alternatives for insect management. These publications provide information about botanical insecticides and insecticidal soaps, microbial pesticides, insect attractants and traps, and biological control organisms (predators and parasitoids).

The entomology group also conducts applied research, often in cooperation with Survey scientists. Our research programs involve many aspects of insect pest management in field crops, vegetable crops, stored grain, livestock systems, urban dwellings, and landscapes. The studies focus on sampling, monitoring with traps, the development of resistance to insecticides, control with insecticides, nonchemical alternatives, and the effects of pest attack on plants and animals.

Extension entomologists also conduct annual and periodic surveys of insects in agricultural systems. In cooperation with other Survey scientists, we have conducted an annual survey of the fall population of European corn borers since 1943, the longest existing record of corn borer populations in the United States. With the help of numerous volunteers throughout the state, we operate a network of pheromone traps that monitors the flights of black cutworm and corn earworm moths. We have also coordinated surveys of insect pests in stored grain and an ecological survey of a number of agricultural systems, including sustainable systems.

Extension entomologists help to educate Illinoisans about insect management in both agricultural and urban settings. We promote the outreach mission of the Survey as we fulfill our responsibilities to the College of Agriculture. Our efforts to promote integrated pest management and to conserve natural resources are more timely and important now than ever before. If you are interested in obtaining more information about the role of

extension entomology within the Survey and the University, or if you are interested in receiving our publications, contact Kevin Steffey at (217) 333-6652.
Kevin L. Steffey, Center for Economic Entomology

An Interesting Loculoascomycete

An undescribed fungus provisionally called *Byssothecium flumineum* is the ecological dominant on submerged wood in Jordan Creek, a stream in central Illinois. This species is an early colonizer and was found on wood baits submerged for only eight days; however, it also persisted on the same substrate for 30 months. Laboratory studies suggest that part of its success in maintaining itself on a substrate may be due to its competitive ability. *Byssothecium flumineum* ranked tenth among 25 aquatic lignicolous species in ability to inhibit other species and ninth in ability to resist inhibition by other species.

Persistence on substrates is likely related to several characteristics of *B. flumineum*. In culture, this species grows

A mature sexual spore (ascospore) of the fungus *Byssothecium flumineum* (x 2,500). The photograph was made with a scanning electron microscope by J. Leland Crane.

at temperatures ranging from 10 to 30°C, with maximum growth at 22 to 25°C. Stream temperature in Jordan Creek ranges from 0 to 27°C, thus *B. flumineum* is able to grow in all but the coldest months of the year. This fungus is able to break down decaying plant vegetation in freshwater systems and is therefore important in ecosystem cycles.
J. Leland Crane, Center for Biodiversity, and Carol A. Shearer, Department of Plant Biology, University of Illinois at Urbana-Champaign

Attention Science Educators

Legacy of a Pest, a series of educational activities developed at the Survey, has proven a useful and exciting supplement to middle school science programs. Michael Jeffords, one of the developers, has conducted workshops for teachers throughout Illinois, and these materials have been well received at each worksho Although designed to provide information on an important introduced insect, th gypsy moth, *Legacy* has far exceeded tha goal. Its more than 50 activities provide a mini-curriculum in entomology, an often neglected area in science programs, and a the same time help students understand important ecological and environmental principles. In addition to classrooms, the activities are suitable for nature centers, park districts, and other settings that offe formal and informal environmental and science education. Workshops may be scheduled at no charge for teachers or other groups by calling Michael Jeffords (217) 333-5986. *Legacy of a Pest* is also available for $5.00 by writing the Distribution Center at the Survey.

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May 1991 No. 307

Tallying Energy's Environmental Costs

The amount consumers pay each month or electricity doesn't cover the cost of the nvironmental damage caused by its roduction. For example, a coal-burning ower plant, even if it complies with overnment pollution-control regulations, till releases air pollutants that contribute o acid rain, smog, and global climate hange. The cost of this residual environ-ental impact has not been figured into e price of electricity.

Survey researchers, like other scientists round the country, are now trying to ssign a price tag to the environmental amage caused by various methods of roducing electricity. This cost can then e figured into calculations used by state tility commission officials considering pproval of new energy services. Evalu-ed with an adjusted economic yardstick, nvironmentally damaging methods of enerating electricity previously consid-red a bargain, such as burning coal, may rn out to be more costly than less amaging alternatives heretofore consid-red economically uncompetitive, such as olar power. About half of the 50 state tility commissions are now developing ays to make such monetary adjustments n integral part of their planning process.

Survey researchers are also beginning use estimates of environmental costs to evaluate the relative merits of programs conserve energy. Programs to reduce emand for electricity may in many in-ances prove less expensive overall than uilding more power plants. Including the nvironmental costs assures that energy onservation programs, as well as nvironmentally friendly methods of ectricity production, can compete fairly the marketplace for energy services.

In Illinois, the Department of Energy and Natural Resources is required by law to issue a biennial State Electricity Plan for consideration by the Illinois Commerce Commission. At the request of the Department, graduate student Patrick Hayes and I have evaluated techniques for assessing the environmental costs of generating electricity, techniques that may be incorporated into the next State Electricity Plan. At this time, the environmental cost estimates are intended to be used only to help utility commission officials and other authorities choose among competing energy service alternatives for the state. From the standpoint of economic efficiency, however, these costs should eventually be added to consumers' bills.

Estimating these previously unquantified environmental costs is difficult. One problem is deciding on the boundaries of the issue. For example, should we consider only the environmental effects of a power plant itself, or should we also consider the effects of producing the fuel and equipment that go into the plant? Another problem is assigning a dollar amount to effects such as climate changes induced by greenhouse gases.

Because environmental costs are hard to quantify, estimates vary widely. All investigators seem to agree, however, that these costs equal at least a substantial fraction of today's electricity prices.

Some estimates of the environmental costs associated with various means of generating electricity are shown in the accompanying table. For the Illinois mix of electricity sources, these costs amount to at least $200 per year per person. The wide range of the estimates (a factor of 9) indicates uncertainty of data and approach. The broad range also results partly from widely different assumptions about admissible emission levels in several states. The highest estimates are from California.

The table also helps to demonstrate how the relative costs of various methods

Estimated environmental costs of various methods of producing electricity[1]

Energy source	% Illinois electricity	Environmental cost (cents/kwh)	Cost per citizen (dollars/year)	% Conventional pollution[2]	% Greenhouse effect[3]
Coal	41.8	4.0–35	170–1,520	88–98	2–12
Natural gas	0.5	1.6–8.2	2–11	70–93	7–30
Oil	1.1	1.0–3.2	1–2	61–90	10–39
Nuclear	56.5	0.5–3.1	29–181	100	0
Solar	0.0	0.4		NA[4]	NA
Wind	0.0	0.1		NA	NA
Total			202–1,714		

[1]The ranges shown represent the variation in values as estimated by three independent research groups and utility commissions in New York and California. For comparison, Illinois utility companies charge about 7 cents per kilowatt-hour (kwh) for electricity.
[2]The percentage of environmental cost from acid rain, smog, etc.
[3]The cost of planting trees to sequester carbon dioxide, which is a transient measure that no longer applies as a forest matures.
[4]Not available.

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of generating electricity may change when the environmental effects are added in. For example, the conventionally calculated cost of electricity from coal-burning plants and solar facilities may be, let's assume, 6 and 11 cents per kilowatt-hour, respectively, making solar power seem economically uncompetitive. But when we add the environmental costs, conservatively estimated at 4 cents per kilowatt-hour for a coal-fired plant but at only about half a cent for solar power, the total costs of the two methods of producing electricity are similar. If we use higher estimates for the environmental costs of coal-burning plants, as some experts have suggested, then electricity based on solar power becomes even less expensive than power generated by burning coal.

Clearly, estimates of environmental costs are highly uncertain, and their use is subject to political winds. Nonetheless, they reflect a useful step toward a greater appreciation of the ecological impact of providing energy services, a useful step toward an "ecological" economics.
Robert Herendeen, Center for Aquatic Ecology

Survey Forefather Cyrus Thomas

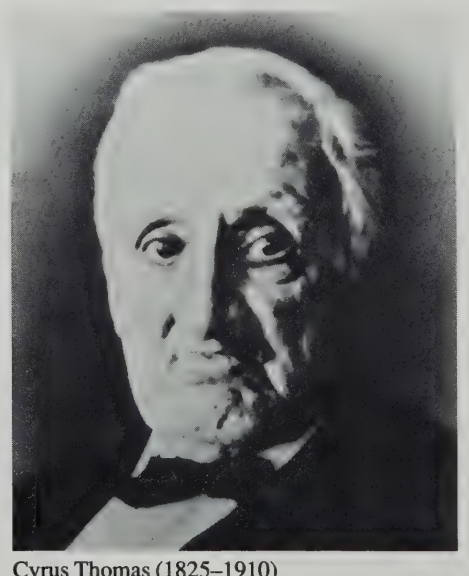
Cyrus Thomas is an important but relatively obscure figure in the 132-year history of the Illinois Natural History Survey. A founder of the Illinois State Natural History Society, the first predecessor organization of the Survey, he became well known for his research on insects, as well as for his later studies in anthropology. Although Thomas worked in a variety of occupations before beginning a serious study of natural history when in his 30s, his subsequent scientific career rivaled that of Stephen A. Forbes, the first chief of the Survey.

Thomas was born in Kingsport, Tennessee, in 1825, and was urged by his mother to become a physician. His interests lay in other directions, however, and as a young adult he was at various times a lawyer, county clerk, teacher, and minister.

Thomas's interest in natural history apparently grew during the 1850s in the midst of a nationwide natural history movement. Many states at that time started natural history societies and surveys, though most were short-lived.

In 1857, while practicing law and teaching in Murphysboro, Illinois, Thomas sent a letter to the Illinois State Teachers Association that was read at the group's December meeting. The letter—which advocated creating an organization to study the flora, fauna, geology, and mineralogy of Illinois—led to the founding of the Illinois State Natural History Society.

The Society was formally organized in Bloomington on June 30, 1858, and Cyrus Thomas was named one of nine vice presidents. The next year he was elected the first curator of the Society's rapidly growing museum collection (Stephen A. Forbes was to become the fourth curator of this collection). Thomas was only an advisory curator because the museum was in Bloomington and he lived in Jackson County, in southern Illinois. Although the museum was dormant during the Civil War, it was revived by John Wesley Powell, a professor of geology at Illinois Wesleyan University in Bloomington. In 1867 Powell became the museum's curator, and Thomas enjoyed a long association with Powell.



Cyrus Thomas (1825–1910)

Thomas first studied entomology rathe than another science because, according t one source, the costs were low and the materials close at hand. He published his first paper on insects in 1859 and continued publishing on this subject for more than 20 years. His interests remained varied, however. In 1858 Thomas sent to the first meeting of the Natural History Society a list of plants that represented th beginning of a survey of the flora of Jackson County. He also published a list of the mammals of Illinois in 1861. During these early years, he earned a living primarily as a lawyer (1851–1864) and then as a minister in the Evangelical Lutheran Church (1864–1869).

His occupation and avocation merged in 1869 when he took a job as a naturalist and entomologist for the Hayden Geologi cal Survey of the Territories, which was a government-sponsored expedition to the American West. In 1874 he joined the faculty of the newly established Southern Illinois Normal University at Carbondale and a year later he became the third State Entomologist (1875–1882) (Stephen A. Forbes was to become the fourth State En tomologist). Thomas also served on the U.S. Entomological Commission from 1877 to 1882 along with renowned entomologists C.V. Riley and A.S. Packard, Jr. Although Thomas never attended college, he was awarded a doctorate from Gettysburg College in Pennsylvania based on a two-part paper reviewing Darwin's work.

While with the Hayden Survey, Thomas had become interested in anthropology, and he started publishing in that area in 1873. His last career move was his appointment at age 57 to the Smithsonian's newly established Bureau of American Ethnology, whose first director was John Wesley Powell. In anthropology, Thomas became well known for his work on Mayan hieroglyphics and for clarifying that the "mound builders" were from known North American tribes rather than from a separate race no longer found in North America at the time of its

iscovery by Europeans. Thomas's ffiliation with the Bureau lasted until his eath at age 85.

During his long and varied career, homas made lasting contributions to two istinct sciences, entomology and anthrology. As a founder of the Illinois State atural History Society and as the third tate Entomologist, he set the stage for the ork of Stephen A. Forbes. The intellect, ide-ranging interests, and drive of Cyrus homas make him one of the Survey's ost distinguished forefathers.

arla Heister, Library

ish Recovery in Depopulated Streams

ream fishes in Illinois have always been bject to naturally occurring disturnces, such as the 1988–1989 drought, in hich many headwater streams cometely dried up. In addition, stream fish mmunities are exposed to humanduced perturbations, including toxic aste and chemical spills. Understanding ese disturbances is important for edicting the effects of water extractions, nd-use changes, and pollution in order to velop prevention and mitigation ategies.

The return of fishes to disturbed areas known as colonization. There have been any investigations of fish colonization in eam ecosystems, including a pioneering rvey study of the return of fishes to nith's Branch in Vermilion County, inois, after the drought of 1953–1954. one, however, has estimated the rate of h colonization or identified factors that nificantly affect the rate. Furthermore, ne has attempted to relate fish colonizan to theoretical models, the next logical p in a process that may ultimately lead a predictive model of fish colonization streams.

In a Survey fish colonization study nducted from late spring to midmmer in 1987 and 1988, relatively ort segments of streams within Champgn and Vermilion counties were ocked off and sampled with an electric ne. Each fish collected during this procedure was identified by species, measured, and marked with a small caudal fin clip that did not impair its swimming ability. Marked fish were then returned to the blocked-off area. To quantify the efficiency of the collection method, the site was then treated with rotenone (a rapidly biodegradable fish toxicant) to kill all fish within the site. These experiments avoided areas with endangered species, and only 150 feet were treated for every 13 miles of stream. After passing through the site, the rotenone was detoxified at the lower blocknet with potassium permanganate, and all affected fish were removed.

After predetermined periods of time ranging from 0.5 to 139 hours, streams were reentered and blocknets were set at the original locations. Each area was resampled once with an electric seine.

The colonization of these relatively short reaches was rapid. Models of fish colonization based on our findings and on theoretical considerations suggest that fish densities return to within 95% of predisturbance levels in 110–420 hours and that fish communities return to within 95% of their predisturbance composition in 80–250 hours. Colonization is expected to be faster in early spring and fall when water levels are higher and seasonal movements to and from overwintering habitats are prevalent.

Colonizing fish are most likely transported from unaffected upstream and downstream areas by a combination of swimming and drifting. Significant differences in species' colonization rates (see accompanying list) can be attributed to differences in short-range movement patterns based on behaviors, such as foraging. A species that actively chases or searches for prey, for instance, would be expected to colonize a short stream segment faster than a species, such as the grass pickerel, that waits to ambush prey. In longer reaches, colonization rates are influenced over longer time periods by other factors, including the habitat preferences of the species, the size and age of colonizing individuals, and the season.

Colonization Rates of Various Fish

Fast
Silverjaw minnow (*Ericymba buccata*)
Green sunfish (*Lepomis cyanellus*)
Blackstripe topminnow (*Fundulus notatus*)
Spotfin shiner (*Cyprinella spilopterus*)

Moderate
Sand shiner (*Notropis ludibundus*)
Creek chubsucker (*Erimyzon oblongus*)
Smallmouth bass (*Micropterus dolomieui*)
White sucker (*Catostomus commersoni*)
Common stoneroller (*Campostoma anomalum*)
Hornyhead chub (*Nocomis biguttatus*)
Northern hog sucker (*Hypentelium nigricans*)
Redfin shiner (*Lythrurus umbratilis*)
Bluntnose minnow (*Pimephales notatus*)
Grass pickerel (*Esox americanus*)
Rock bass (*Ambloplites rupestris*)
Longear sunfish (*Lepomis megalotis*)

Slow
Striped shiner (*Luxilis chrysocephalus*)
Creek chub (*Semotilus atromaculatus*)

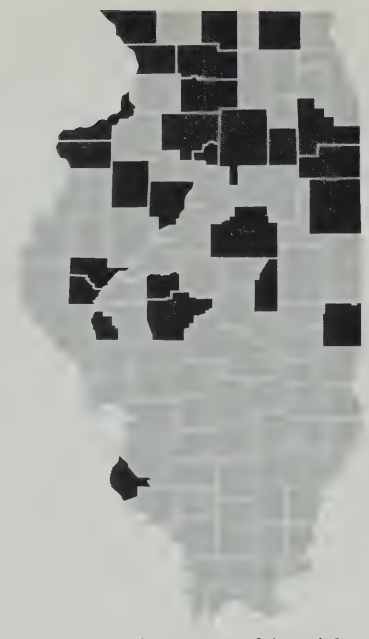
Our study suggests a need to reevaluate stream management practices, especially the stocking of recently decimated streams with the aim of reestablishing the fish community. In stream ecosystems dominated by surface runoff, the fish community can quickly return to predisturbance population levels and composition without human assistance, providing that the environment returns to its original state. In addition, Midwestern stream fish communities consist of many different species, most of which are not easily available for stocking. These two facts should make it apparent that stocking is usually infeasible or unnecessary, except when managers are trying to reestablish endangered species in restored habitats. The best management policy, in general, seems to be to allow the fish community to recover naturally. Therefore, mitigation funds may be better spent on improving the stream habitat rather than on stocking fish.

James Peterson and Peter Bayley, Center for Aquatic Ecology

Deer Tick Update

The deer tick, which spreads the bacteria that cause Lyme disease, is expanding its range in Illinois. In a recent statewide inspection of hunters' deer, this tick was found in eight counties in which it had not previously been reported. For the first time, the deer tick was found in the southern one-third of the state.

During November and December of 1990, researchers from the Survey, the College of Veterinary Medicine of the University of Illinois, and the Illinois Department of Public Health searched for ticks at Illinois Department of Conservation deer check stations. With the aid of many volunteers, more than 5,000 deer were examined at stations in the 98 Illinois counties that permit firearm hunting. The eight counties in which the deer tick was found for the first time were Will, Iroquois, Grundy, LaSalle, Bureau, Schuyler, Scott, and Monroe. This tick has been detected in 26 Illinois counties since surveying began in the fall of 1987.



Illinois counties with reports of deer ticks as of December 1990.

Cases of Lyme disease continue to be reported to the Illinois Department of Public Health from throughout the state.

Anyone engaged in outdoor work or recreation in Illinois is thus advised to ta precautions against tick bites. In a tick-infested area, the best protection is to we sturdy shoes, long pants with cuffs tucke into socks, and a long-sleeved shirt. Additional protection can be obtained by applying tick-repelling sprays to clothin not to the skin.

In addition, public health officials no urge anyone who handles or dresses wil animals to wear rubber gloves to help prevent the spread of Lyme disease by exposure to infected blood. They also recommend that venison and other game be thoroughly cooked before eating.

Anyone wishing to submit ticks for identification should send them in alcoh to John K. Bouseman at the Survey's Center for Economic Entomology.

John K. Bouseman and Uriel D. Kitron (affiliate), Center for Economic Entomology

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Iedical Entomology Program

Iosquitoes are not only a nuisance but so a threat to public health in Illinois. Iany species of mosquitoes carry viruses at can be transmitted to humans when e insect pokes its proboscis into its ctim's skin in search of a blood meal. hese viruses can then cause human seases such as St. Louis encephalitis, a ometimes fatal affliction that involves flammation of the brain.

Illinois public health officials have een especially concerned about the Asian ger mosquito, a relatively recent nmigrant to the United States. This osquito, which often lives in piles of ed automobile tires, transmits the ruses that cause St. Louis and La Crosse cephalitis. La Crosse encephalitis, a sease of children, has up to now been nited to rural or suburban areas because has been transmitted primarily by a ecies of mosquito not found in cities. ith the establishment of the Asian tiger osquito, a city dweller, La Crosse cephalitis will probably become more mmon in urban areas.

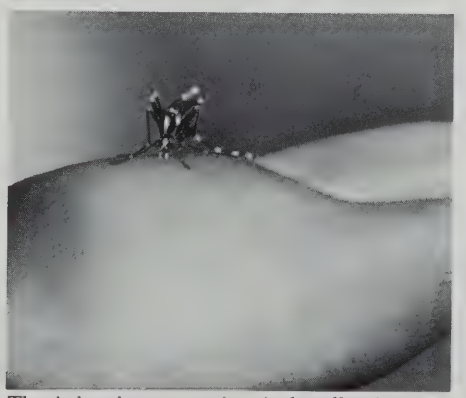
Because these mosquito-borne viral seases cannot be prevented by vaccines effectively treated with antibiotics, eventing widespread outbreaks requires ntrolling the mosquito population. In 89 the Illinois state government passed ecial legislation to address mosquito ntrol, particularly the problem of osquitoes breeding in waste tires. The aste Tire Act included funding for search, and the Natural History Survey bsequently established the Medical En- nology Research Program, geared to udy mosquitoes that live in and around aste tires. Up to now, little information has been available on the many complex aspects of mosquito-related disease problems in Illinois, and virtually no information has been available on the biology and control of mosquitoes found in tire casings and other artificial or natural containers.

The following five reports summarize some of the projects being conducted by the Survey's Medical Entomology Program. We believe that these studies will ultimately help to reduce the threat to public health from mosquitoes in Illinois.

Mosquito Insecticide Resistance

Mosquitoes sometimes develop resistance to certain insecticides. This resistance develops when a genetic alteration that protects one or more mosquitoes against the insecticide is spread throughout the population during successive generations of breeding.

The Medical Entomology Program recently began to use two methods to assess the baseline susceptibility of various mosquito species to selected insecticides. The first involves documenting the acute toxicity of the insecticides to specific populations of mosquitoes in Chicago, East St. Louis, Kankakee, Urbana-Champaign, and Mounds. We are determining the dosages that are necessary to kill a specified proportion of the mosquitoes in these populations. If future tests indicate that a significantly higher percentage of mosquitoes survive at this dosage, then resistance has developed.



The Asian tiger mosquito, *Aedes albopictus*, which transmits the viruses that cause two types of encephalitis.

Because relatively few compounds are government-approved for control of adult and larval mosquitoes, changes in susceptibility of monitored populations will be reported to mosquito abatement districts to prolong the safe and judicious use of the limited chemical arsenal available. In the event of a serious outbreak of a mosquito-borne disease, it is important to know which insecticides will effectively control the virus-bearing mosquito species with minimal impact on the environment and on future control strategies.

The second method to assess susceptibility to insecticides involves electrophoresis, a laboratory technique that can provide a visual profile of the proteins (enzymes) in the mosquito that are likely to be associated with insecticide resistance. Certain changes in the enzyme makeup of a mosquito population over time may indicate that resistance is developing in that population. We have identified a small percentage of northern house mosquitoes, known by the scientific name *Culex pipiens*, that have extremely high levels of an enzyme that may enable them to resist a class of insecticides known as organophosphates.

Using the two monitoring techniques, we have discovered that there are substantial geographic differences in susceptibil-

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ity to insecticides. For instance, adult and larval stages of the Asian tiger mosquito (*Aedes albopictus*) in Chicago are less sensitive to malathion than are strains at other sites in Illinois and Hawaii. We have also observed that each species of mosquito has its own specific profile of sensitivity to insecticides. For example, although *Aedes albopictus* larvae are sensitive to chlorpyrifos, *Culex pipiens* individuals are relatively insensitive.

Ongoing projects include the development of our own strains of *Culex pipiens* and *Aedes albopictus* that are resistant to malathion and permethrin. By observing both resistant and susceptible strains, we may come to more fully understand the mechanisms and genetics of resistance.
Richard Lampman, Robert Metcalf, and Robert Novak, Center for Economic Entomology

Mosquitoes in Tire Piles

During the summer of 1990 we monitored the mosquitoes inhabiting two tire piles in Trelease Woods in Champaign County. One pile was in an oak-maple woodlot, the other in an open meadow.

About 4,500 mosquito larvae were collected from the woodlot tire pile, whereas only about 1,100 were collected from the meadow pile. This difference may be due to the greater amount of leaf litter in the woods tires than in the meadow tires at the beginning of the season. The leaf litter provides nutrients for the mosquitoes.

The species composition of the mosquito populations was also different in the two tire piles. For example, although *Aedes triseriatus* made up more than half of the mosquitoes in the woodlot pile, this species constituted only about one-fourth of the specimens collected from the meadow tires. *Anopheles punctipennis* and *Culex* species may be better adapted to the hotter, nutrient-poor conditions in the meadow pile, whereas *Aedes triseriatus* appears to be better adapted to the cooler, nutrient-rich woods tires.

We also documented changes in species numbers over time. In the woods pile, for instance, the number of *Culex* mosquitoes was very high early in the season, declined dramatically, and then rose again late in summer. We also found that the number of female *Aedes triseriatus* declined in the meadow pile six weeks before it declined in the woods tires. The concomitant increase in numbers of *Anopheles punctipennis* in the meadow tires during this period suggests changes in habitat structure over time.

Greater understanding of the species composition and population dynamics of mosquitoes in tire piles in Illinois will help to make future control efforts more effective.
Robert Melton and Robert Novak, Center for Economic Entomology

Survey researchers monitoring mosquito numbers in a meadow tire pile in Trelease Woods in Champaign County.

Molecular Biology Project

At least 10,000 Americans have contracted St. Louis encephalitis since this disease was first recognized 58 years ago. Although cases occur sporadically every year, urban and suburban epidemics in the central United States occur in cycles of approximately 7–10 years. In 1975 Illinois led the nation in the number of cases and consequent deaths.

The virus that causes St. Louis encephalitis is thought to be brought to Illinois with migrating birds in early spring. The virus is then multiplied in th bird population via a mosquito, *Culex restuans*. After the virus is amplified to a certain point in the bird population, it is transmitted to humans in late summer by *Culex pipiens*, which feeds on both peop and birds.

Preventing widespread outbreaks of S Louis encephalitis requires early detecti of virus activity followed by mosquito control. Ideally, virus activity should be detected during early spring, when the virus is restricted to the bird population. practical method to detect the active viru in birds has heretofore been unavailable.

To develop an effective early warnin system, the Medical Entomology Progra has employed a molecular biology technique known as a polymerase chain reaction, or PCR. The PCR technology can locate minute quantities of a virus, multiply a specific portion of the virus's genetic code, and then accurately identif the virus. Using this technology as part o

n early warning system may help to save ives and limit the suffering associated vith St. Louis encephalitis. Although we ave developed a PCR that can identify ie St. Louis encephalitis virus, further tudies are needed before the technique vill be ready for widespread use. Field tudies this summer will test the feasibil-y of using this new technology through-ut the state.

obert Novak, Center for Economic ntomology, in cooperation with G.L. IcLaughlin, M.H. Vodkin, and D.K. owe, Department of Veterinary Patho-iology, University of Illinois

Iosquito Population Studies

he Medical Entomology Program's udies of mosquito populations have ocused on the species *Culex pipiens* and *edes triseriatus*, which carry the viruses at cause St. Louis and La Crosse ncephalitis, respectively. These studies ere conducted primarily to establish any lationship between increases in seasonal g laying and outbreaks of encephalitis.

In the life cycle of *Culex pipiens*, males often lay eggs in floating groups "rafts" on the surface of water in natural d artificial containers. In our studies in ntral Illinois, we found that *Culex piens* egg rafts first appeared in oviposi-on traps in mid-June. Population mbers increased dramatically in early to id-July and remained high through the rst week of October. Estimates of the mber of *Culex pipiens* biting females ring 1988 to 1990 were higher than timates for 1976, the year after the last . Louis encephalitis epidemic. This ggests that *Culex pipiens* population mbers fluctuate widely and that creases in numbers may be related to cephalitis outbreaks.

In 1990 we developed a method to mple eggs from several species of eehole mosquitoes on a weekly basis. ormally, treehole mosquitoes lay their gs on container walls between the ater's surface and the high-water line. In e new method, seed germination papers e mounted on interior surfaces of scarded tires and natural treeholes to monitor egg deposition. The germination papers are removed weekly and the eggs counted. This method provides a regular and direct count of egg laying in natural and artificial containers. These studies of egg laying will contribute essential information to our understanding of the life cycles of container-breeding mosquitoes.

In the future, we will compare rural and urban population levels of *Aedes triseriatus* and *Culex pipiens* and will assess *Aedes triseriatus* numbers in specific urban areas. Field tests will determine the visual and olfactory cues that mosquitoes use to find suitable egg laying sites and carbohydrate resources. Ultimately, an understanding of how mosquitoes select oviposition sites and identify sources of carbohydrates and blood-meals will contribute to a broader knowledge of mosquito life cycle requirements and epidemic disease cycles in Illinois.

Bruce Steinly and Robert Novak, Center for Economic Entomology

Diseases of Mosquitoes

The next time you are scratching a mosquito bite, it may comfort you to realize that these insects have their own problems. There are many bacteria, protozoa, and fungi that infect mosquitoes.

Infectious organisms that affect insects are known as entomopathogens. Several bacterial entomopathogens are so effective at quickly killing mosquito larvae, while remaining harmless to beneficial insects and animals, that they are produced commercially and marketed as nonchemical insecticides. Because some mosquitoes have become resistant to some of the chemical insecticides currently available and because people have become increasingly concerned about the effects of insecticides on the environment, interest in the use of entomopathogens as alternative control agents has greatly increased in recent years.

Entomopathogens do not have to kill mosquitoes quickly to help control mosquito populations. Chronic effects

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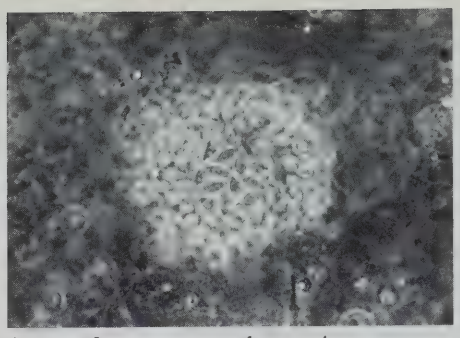
caused by infection, such as decreased lifespan and depleted energy reserves, may prevent mosquito populations from increasing and may limit the ability of a particular mosquito species to become established in another part of Illinois. Environmental stresses such as heavy rain and heat may interact with infection to increase mortality among infected adult mosquitoes. In addition, entomopathogens may decrease the number of eggs that female mosquitoes lay.

Unfortunately, very little is known about how entomopathogens affect mosquitoes because previous research emphasized chemical control measures. The Medical Entomology Program is attempting to rectify this lack of knowledge by conducting surveys of the mosquitoes of Illinois to identify native mosquito entomopathogens. Mosquito larvae collected from tire piles throughout the state have been brought back to Champaign and examined for infections by using a microscope.



Spores of a protozoan pathogen, *Ascogregarina barretti*, inside the pupal stage of a mosquito, *Aedes triseriatus*.

One species of woodland mosquito that breeds in treeholes and tire piles throughout Illinois and that transmits the virus that causes La Crosse encephalitis is infected by a protozoan entomopathogen known as a gregarine. Larvae of this mosquito species, *Aedes triseriatus*, become infected when they ingest the spores of the gregarine while feeding, and the protozoan then undergoes a complex life cycle in the mosquito. The gregarine is spread to new tree holes and tire piles when infected females lay eggs.

Experiments conducted in Trelease Woods in Champaign County in 1990 suggest that mosquito pupae infected wit the gregarine are four to five times more likely to die than uninfected pupae. Infection also depletes female mosquito energy reserves and reduces the size of infected adults. Research is continuing t quantify the effects of this gregarine on *Aedes triseriatus* to determine how the protozoa may affect the population dynamics of this mosquito, and we are continuing to search for new mosquito entomopathogens. As we learn more abo the diseases of the many mosquitoes in Illinois, we will have more options for controlling their numbers.

Joel Siegel, Joseph Maddox, and Robert Novak, Center for Economic Entomology

New Publications Catalog Available

The spring 1991 Survey publications catalog is now available. For a free copy, please write to Distribution Center, 172 Natural Resources Building, 607 East Peabody Drive, Champaign, IL 61820.

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eptember 1991 No. 309

escuing the Royal Catchfly

hree hundred fifty-six species of ascular plants are considered endan-ered or threatened in Illinois. Most have eclined because of habitat destruction, hich has been so extensive that certain lants persist only in disturbed locations, uch as roadsides. One endangered plant, e royal catchfly, survives at only four isturbed sites in Illinois.

A two-year study of the biology and cology of the royal catchfly, *Silene gia*, was conducted by Survey re-earchers with funding from the Illinois ndangered Species Protection Board. he aims of this investigation included etermining the current status of this ant and recommending management to revent its extirpation.

The royal catchfly has apparently ways had a restricted range in Illinois; has been absent from the western and ntral parts of the state, despite seem-gly suitable habitat there. Most reports royal catchfly populations are from rmer prairie regions in southeastern and uthwestern Illinois, which were among e first regions to be plowed by Euro-an settlers. There are few prairie mnants in these areas. At some loca-ons, the well-drained soils are cultivated ght to the road shoulder, leaving no adside vegetation. Prairie remnants in ilroad rights-of-way continue to be nverted to cropland when the railroad es are abandoned. In addition, urban velopment has destroyed many prairie mnants that were spared from conver-on to cropland. The royal catchfly pears to be restricted to those portions Illinois where destruction of prairies d prairie remnants is complete.

The four remaining locations of the royal catchfly are a cemetery and a roadside in Lawrence County, a fence-row in Clark County, and a railroad right-of-way in Madison County. None of these sites are prairie remnants, nor any kind of natural community. A few prairie plants are present at these sites, but the dominant forms of vegetation are herbs and shrubs typical of disturbed ground throughout Illinois. The royal catchfly probably colonized these locations before adjacent prairies were destroyed.

Extensive monitoring of the populations indicated that individual plants may be long-lived and vigorous, developing multiple stems with numerous flowers. Even during the drought of 1988, two of the four populations produced abundant seeds. Despite abundant seed production in some populations, however, almost no seedlings were found during monitoring of royal catchfly populations.

Some populations apparently have not received sufficient sunlight, which is necessary for seed germination, growth, and flowering. Experiments comparing the effects on royal catchfly of light levels, nutrient levels, and soil texture found that light was the most important factor for growth and flowering. Before the colonization of Illinois by Europeans, prairie fires normally removed dead vegetation and killed woody species that otherwise would have shaded royal catchfly plants and seeds. The lack of prairie fires today results in increased shade. In addition, frequent mowing of

Location of extant (●) and extirpated (○) populations of royal catchfly in Illinois. The plant is normally about 1 meter tall and has brilliant scarlet flowers. Photo by Eric Ulaszek.

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sites may have prevented flowering and seed production.

The dispersal of the royal catchfly may have been limited by the nature of its seeds, which lack structures that would aid in wind or animal distribution. When Survey researchers set up seed traps at selected distances from royal catchfly plants, seeds were captured only immediately beneath the plants.

The four remaining populations of the royal catchfly are not secure. During the monitoring period, the two Lawrence County populations were mowed, the Clark County population had a brush pile placed upon it, and the Madison County population was sprayed twice with herbicide. Shade from adjacent trees and shrubs has reduced flowering and seed set in two populations. The Clark County population was nearly destroyed in 1989 when the landowner bulldozed most of the site. Although one of the Lawrence County populations is adjacent to a cemetery whose directors have agreed to protect the site, this location, only 3 meters wide and 30 meters long, is vulnerable to vandalism and accidental destruction.

One way to prevent the extirpation of the royal catchfly from Illinois is to re-establish this species in prairies. Although there are few, if any, suitable prairie remnants near the surviving populations, there are proposals to create prairie restorations near several royal catchfly sites, and the plant could be introduced into a restoration. Survey researchers are now conducting an experimental introduction at a prairie reconstruction at the Survey arboretum. Royal catchfly seeds were sown in the autumn of 1987, but because of drought and competition from established prairie grasses, only two plants were successfully established. Subsequently, royal catchflies grown in greenhouses were transplanted into the restoration in September 1988. Fifty-five percent of these plants survived to 1990, and 45 percent of the survivors flowered and set seed in 1990. Searches for seedlings are being conducted in 1991. If the royal catchfly successfully reproduces at the Survey prairie, then its introduction into prairie restorations may prove important for preserving this endangered plant.

Eric Ulaszek and David Ketzner, Center for Biogeographic Information, and Louis Iverson, Center for Biodiversity

Of Sap Movement and Branch Pruning

The pattern of sap movement at the branch and stem juncture in trees and shrubs is not clearly understood. The function and anatomy of the branch base is important for determining where pruning cuts should be made.

The raised or swollen area at the base of a branch has been referred to as the shoulder, branch collar, or trunk collar. Previous Survey studies demonstrated that cuts through the shoulder close more quickly than cuts outside the shoulder, and some people also consider the former cuts to be more aesthetically pleasing. Nonetheless, a prominent tree expert, Alex Shigo, has recommended making the final cut outside the collar to avoid discoloration and decay of the stem.

Survey experiments in 1989 and 1990 investigated the hydraulic architecture of the branch-stem juncture by injecting a water-soluble dye into stems beneath branches. The branches were excised five to seven days later, and the patterns of dye translocation were traced from the stem into the branch. Eight species of trees were treated at eight dates throughout the growing season, but patterns of dye movement did not vary among species or with time of year.

Pattern of sap movement at the stem-branch juncture.

Dye injected directly beneath a branch moved distally straight up into the branch. Dye injected below but not directly beneath a branch moved into the sides or top of the branch. The greater the lateral distance from directly beneath the branch, the more likely the dye would move from the side of the branch to the top of the branch. Dye injected beyond the branch shoulder moved around the branch and continued up the stem.

Most textbooks illustrating the juncture of stem and branch show a direct connection between wood on top of the branch and wood on the stem directly above the branch. Shigo recently established, however, that there is little or no direct structural or conductive tissue in this branch crotch area. His observations were confirmed by the present studies. In addition, Shigo documented the abrupt turning into the branch of stem xylem from below the branch, also confirmed in our study. This "ball and socket" arrangement in trees is readily observed when excessive weight is applied to branches.

Shigo has further stated that the collar at the base of a branch is composed of branch tissue early in the growing season and stem tissue late in the season, but this hypothesis was refuted by the present study. The stem and trunk tissues remained separate and distinct throughout the study.

I believe that a "collar" forms only around dead or dying branches as callus tissue of the stem attempts to overgrow branch tissue. I also believe that "shoulders" at the base of all vigorously growing branches are the result of food materials being available from both stem and branch tissues, which leads to the enlargement.

Dan Neely, Center for Biodiversity

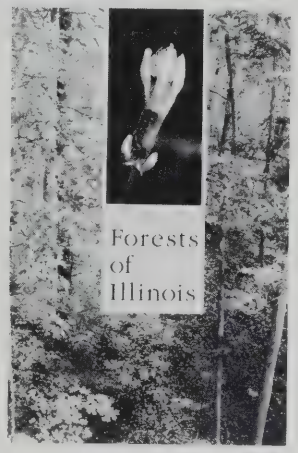
ew Publications Roundup

everal new Survey publications have een issued in recent months. One is the roceedings of a symposium held in association with Earth Day 1990. Titled *Our Living Heritage: The Biological Resources of Illinois*, this book is divided into sections on forests, prairies and barrens, wetlands, streams and caves, and agro-urban ecology. Twelve full-length ticles and seven summaries of sympo- um presentations describe the status of ological resources in each of the Illinois osystems. An appendix lists all native inois taxa and numbers of species in ch taxon; it also notes the number of reatened or endangered species in each xon and identifies 115 species pre- med extirpated from the state. Edited Survey scientists Lawrence Page and chael Jeffords, this 120-page, illus- ted publication is article 4 of Survey lletin volume 34. It is available from Survey for $3.

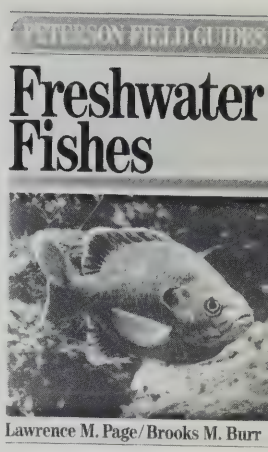
A new Survey publication for experts fungi is titled *A Nomenclator of ptosphaeria V. Cesati & G. de Notaris*. itten by Survey mycologist J.L. Crane d University of Illinois plant biologist A. Shearer, this book lists nearly 1,700 cies, varieties, and forms within the us and indexes the taxa by host, host ily, substrate, and geographic area. is 160-page book, which is article 3 of lletin volume 34, is available from the vey for $3.

A third recent publication is titled *A vey of the Freshwater Mussels valvia: Unionidae) of the Sangamon er Basin, Illinois*. Also known as vey *Biological Notes* 137, this 28- e publication describes the abundance distribution of individual species in Sangamon River basin and compares current status with that documented earlier studies, dating back to 1910. itten by Robert Schanzle of the Illinois Department of Conservation and Kevin Cummings of the Survey, it is distributed for $2.

A 24-page booklet titled *Forests of Illinois* is also now available. Produced by the Survey in cooperation with the Illinois Council on Forestry Development, this nontechnical publication is designed to increase understanding and appreciation of the forests of the state. Illustrated with numerous beautiful color photographs, the booklet is available free of charge in limited quantities from the Survey.



Finally, Survey ichthyologist Lawrence Page and Brooks Burr of Southern Illinois University in Carbondale recently authored *A Field Guide to Freshwater Fishes: North America North of Mexico*. This is the first guide to cover all 790 species in the United States and Canada, and it includes more than 700 illustrations and nearly 400 detailed maps. This Peterson field guide is published by the Houghton Mifflin Company and is not available from the Survey.



To order any of the first four publications mentioned, please write to Distribution Center, Illinois Natural History Survey, 607 E. Peabody Drive, Champaign, Illinois 61820 (or call 217-333-6880). A free catalog of all Survey publications can be obtained by writing to the same address.

John Ballenot, Publications Office

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Species Spotlight: The Creek Chub

One of the most common fishes in Illinois, the creek chub is also one of the most interesting. The nest-building and other spawning-related behaviors of this large minnow make for quite a show in late spring and early summer in small streams and ditches throughout the state.

For the breeding season, males change from olive green to rosy pink and develop tubercles on the head, body, and fins. The tubercles function like the antlers of deer and are shed at the end of the breeding season. The head tubercles are used symbolically to assert dominance over competing males and to attract females.

Males build nests by digging small pits in the stream bed with their mouths and then depositing mouthfuls of gravel at the upstream side of the pit. When a female comes to spawn, the male grasps her with his fin and body tubercles as she releases the eggs, which he fertilizes and covers with gravel. The nest expands as the male spawns with other females.

Although only one male is dominant over a nest at any one time, the dominant male is often challenged by others. If the challenger is small, the dominant male may rebuff the contender simply by turning his head to display his large tubercles. But if the challenger is about the same size as the dominant male, a long ritualistic display called a parallel swim ensues. The dominant male usually returns to find that he must chase away a small male that has taken over the nest. Small males do not build nests of their own but wait for dominant males to leave and then take over. This is called a satellite male strategy and is common throughout the animal kingdom.

A male creek chub. Note the head tubercles. Photo by Eugene C. Beckham.

Found throughout eastern North America, the creek chub, *Semotilus atromaculatus*, is a hardy fish that eats insects and other small aquatic organisms. To observe its springtime activitie just put on a pair of polarized sunglasse pick a spot next to a stream, and wait fo the show to begin.

Carol Johnston, Center for Biodiversity

Editor's Note

The previous article inaugurates our "Species Spotlight" series. Henceforth, each issue will include a "Species Spotlight" article on a particularly inter esting or important Illinois species, ofte a threatened or endangered organism.

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ctober 1991 No. 310

ebra Mussel Alert

n June 18, biologists from the Survey's eld station at Havana received a zebra ussel, *Dreissena polymorpha*, that had en taken alive the previous day from e Illinois River by a commercial ammer. The mussel was taken from ath Chute, a side channel about 200 iles downstream from Chicago. This is e first confirmed sighting of this pest in e Illinois River proper and the first in e Mississippi River drainage. By aching in large, dense colonies to derwater objects, such as water intake pes and boat hulls, zebra mussels can use great economic damage; by tering large amounts of water for ankton, these small invaders from rope can devastate the food supply of h and other species.

Zebra mussels were probably intro-ced into the Great Lakes in 1985 or 86 when ships from Europe discharged shwater ballast that contained the free-imming larvae. The mussel has already come a serious economic pest in Lakes e and Ontario. On southern Lake chigan, utilities and steel plants have reased their biofouling control atments to prevent zebra mussel estations. According to the Great kes Sea Grant Network, the invasion of zebra mussel may ultimately cost lions of dollars, far more than the cost all previous Great Lakes invaders nbined.

Zebra mussels most likely spread from ke Michigan via the waterways of icago into the Illinois River. After the t specimen was found in Bath Chute, ond and third specimens were taken from the main channel of the Illinois River by a commercial clammer approximately 240 and 250 miles downstream from Chicago. These mussels occurred well downstream of the last dam on the Illinois River, only 50–60 miles from the confluence with the Mississippi River. These widespread sightings in the Illinois River, including a chute that commercial barges do not enter, suggest that the mussel is reproducing in the river and not merely dropping off barges or other boats traveling from the Chicago area.

The Survey's field station on the Mississippi River has been alerted, and a sampling program for adult and larval zebra mussels has been initiated on both rivers in cooperation with Dr. Andrew Miller of the Waterways Experiment Station, U.S. Army Corps of Engineers, and with Ms. Pamela Thiel of the Long-Term Resource Monitoring Program, U.S. Fish and Wildlife Service. The sampling methods were developed by Dr. Ellen Marsden of the Survey's Lake Michigan Biological Station. In addition to monitoring the spread of the mussel, the sampling program will test the efficacy of different coatings in preventing the attachment of the mussels.

All of the collected mussel specimens are a little less than 1 inch long, so they are probably two or three years old. If they entered the river as larvae, the invasion actually took place in 1988 or 1989. The little invader poses a serious

The approximate distribution of the zebra mussel in the Great Lakes and the Illinois River.

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Zebra mussels form dense colonies on underwater objects. What look like grains of sand on the adult mussels (pictured slightly larger than life-size) are actually zebra mussel juveniles.

threat to the native mussels of the river, including species that already are threatened or endangered, because it grows over their shells and may interfere with their siphoning. All three specimens collected were firmly attached to native three-ridge mussels, *Amblema plicata*, a species whose pure white shells are used as starting material in the Japanese cultured pearl industry.

In addition, Survey researchers have found recently that the zebra mussel infestation of Lake Michigan has increased in severity. The first adult zebra mussel was discovered in Lake Michigan in late 1989, and in 1990 several industries and public utilities found zebra mussels in low numbers inside their intake pipes. This year, underwater inspections of intake pipes and natural substrates have revealed adult mussels 1/4 to 1 1/4 inches long along all of the Illinois and Indiana shorelines of the lake. To date, the highest densities of adult and juvenile mussels have been noted in the southern portion of the lake, with up to 50,000 juveniles per square yard settling onto monitoring plates. Studies by the Survey's Lake Michigan Biological Station have also indicated that newly hatched zebra musssels (veligers) appeared in the water in mid-June and began to settle onto hard substrates in late July. Because veligers spend up to five weeks of their lives as freely drifting plankton, they can be readily carried by currents from the lake into the Chicago waterways and into the Illinois River.

The Survey needs specimens to document the spread of the zebra mussel. A sighting is not considered confirmed until a voucher specimen has been positively identified and deposited in a nationally recognized scientific collection, where experts can examine it. The first specimen from the Illinois River was deposited in the Survey mollusk collection by malacologist Kevin Cummings, and the second was sent to the Ohio State Museum.

Confirmed sightings are important because the water quality characteristics associated with each new locale can help define the environmental requirements of the species. Biologists can use such information to predict the eventual range of the mussel in North America as well as those areas where it is likely to become a serious economic pest. For example, because the zebra mussel prefers cool water, it may not thrive in southern portions of the Mississippi drainage or where there are warm-water discharges.

Identifying the zebra mussel is fairly easy because this mussel and one other invader (the dark false mussel, *Mytilopsis leucophaeta*) are the *only* mussels that firmly attach themselves to solid objects. If you find a zebra mussel, please note the date and precise location. If possible, leave it attached to the object and keep it alive by putting it on ice or in a refrigerator, or preserve it in rubbing (isopropyl) alcohol. If the specimens are from the Illinois or Mississippi rivers or their tributaries, please contact Mr. K. Dougl Blodgett, Long-Term Resource Monitor ing Station, Illinois Natural History Survey, 704 North Schrader Avenue, Havana, IL 62644 (phone: 309-543-6000). For specimens found in Lake Michigan or its tributaries, please contac Dr. Ellen Marsden, Lake Michigan Biological Station, Illinois Natural History Survey, P.O. Box 634, Zion, IL 60099 (phone: 708-872-8676).

Richard Sparks and Ellen Marsden, Center for Aquatic Ecology

The Winter Tick

The winter tick, *Dermacentor albipictus* is found throughout the United States an in much of Canada. The hosts of the winter tick are large animals such as dee elk, moose, caribou, reindeer, cattle, and horses. In some areas the winter tick, which resembles the closely related American dog tick, is also known as the "elk tick" or "moose tick." The tick's active immature stages (larvae and nymphs) and adults are found on the hosts during fall and winter. In the case the larger host species, hundreds of thousands of the tick may be found on a single individual.

Collections of ticks from hunter-kille deer have demonstrated that the winter tick is widespread and prevalent in Illinois, especially in areas with large populations of white-tailed deer. Becaus of the large numbers that can be present on a single deer, the ticks are often noticed by hunters, who may mistake these for deer ticks, which transmit the bacteria that cause Lyme disease. The winter tick, however, does not ordinarily bite people and is not known to transmit disease-causing organisms.

Anyone wishing to submit ticks for identification should send them in alcoh to John K. Bouseman at 607 East Peabody Drive, Champaign, IL 61820.

John K. Bouseman, Center for Economi Entomology

ar-flung Soybean Relatives

he evolutionary ancestor of the domes-
c soybean probably originated in East
sia. This ancestral soybean, as well as
her forerunners of the genus *Glycine*,
en apparently spread to what is now
ustralia millions of years ago, before
adual shifting of the Earth's crust had
parated the two land masses.

Glycine species evidently returned to
ast Asia from Australia millions of
ears later, after the two continents had
come separated by a vast ocean. Some
ild *Glycine* species that evolved in
ustralia, according to chromosomal
idence, are now also found on large
lands off East Asia. For instance,
lycine tabacina is found in Japan,
aiwan, the Pescadores, and the Marianas
well as Down Under. When R.J. Singh
d T. Hymowitz of the University of
inois crossed Australian with Asian
rsions of *Glycine tabacina*, the
fspring were fertile, so we know that these plants are members of the same species. At the request of the University researchers, I have sought to help solve the mystery of how these plants could cross thousands of miles of ocean.

The seeds of these plants provide few clues. They are small, dark, and rather smooth. Placed in sea water, they sink. Neither seeds nor pods would stick to the coat of an animal. Unlike the modern domestic soybean, they are not known to be consumed by humans and thus probably would not have been purposely transplanted by early Pacific peoples.

The most likely explanation for the far-flung distribution of the soybean's relatives is migratory birds. Long-distance dispersal of seed by birds is well-documented, with seeds being transported either in mud sticking to the feet or in the digestive tract (after either accidental or intentional ingestion). In fact, studies have shown that seeds similar to those of *Glycine* can be retained in the digestive tract of birds for more than 100 hours and then excreted in a viable form. Even raptors can transport seeds by consuming the stomachs of prey animals that have eaten the seeds. Viewed from this perspective, the small, light, tough seeds are good candidates for traveling airmail.

In addition, bird banding studies have shown that certain gulls, pigeons, swifts, and shorebirds migrate annually from Australia to Asia. Radar has also detected presumed shorebirds passing southward over Guam in the Western Pacific, verifying that ocean expanses are no barrier to migrating birds.

Ronald P. Larkin, Center for Wildlife Ecology

e plant *Glycine tabacina* (photo) somehow spread thousands of miles across the ocean from
ıstralia to the Mariana Islands, Taiwan, the Pescadores (near Taiwan), and Japan. Its seeds are
ıaller and darker than those of the domestic soybean (both types are pictured in palm of hand).

New Educational Materials

A new set of six black-and-white educational posters is now available from the Survey. The 11" x 17" posters are titled *Trees of Illinois, Illinois Forests, Making Tracks, Family Tree of Insects, Illinois Wildflowers,* and *Illinois Fishes*. The set comes with a list of suggested study questions (and answers), which are designed to pique interest in the organisms depicted and to lead students toward a better understanding of natural processes. The poster set is appropriate for elementary and junior high science classes, nature centers, and other biology-oriented groups such as scouts and 4-H. Individual sets are 25 cents; classroom sets of 30 are $7.

In addition, a 17" x 22", black-and-white coloring poster titled *Biodiversity in Illinois* continues to be available. This poster pictures more than 60 plants and animals native to Illinois and comes with an anwer key identifying each organism. Individual posters are 15 cents, and classroom sets of 30 are $3.50. To obtain copies of any of these posters, send a check or money order to the Distribution Center, Illinois Natural History Survey, 607 East Peabody Drive, Champaign, IL 61820.

Michael Jeffords, Educational Liaison

Species Spotlight: The Locust Borer

Among the showiest and most common fall flowers are goldenrods. Look closely at the blossoms and you may see a variety of small creatures that are somewhat difficult to detect because they are the same color as the flowers. Some of these are predators, such as crab spiders and ambush bugs, that use their concealing coloration to more easily capture insects that come to feed on the goldenrod pollen and nectar. One of the most spectacular insects that feed on goldenrod pollen is the locust borer.

Adult locust borers are black with yellow markings that are shaped into W's, bands, stripes, and other patterns. They are about 1 inch long and have long, thick, black antennae that curve gracefully behind the head. Like many other beetles, they pollenate plants as they fly from flower to flower.

Adult locust borer females lay their eggs in bark crevices, and the hatching

A locust borer adult on a goldenrod blossom.

larvae tunnel through the bark into the wood underneath. The borers attack the trunks and larger branches of black locust trees that are between 2 and 6 inches in diameter. The destructive larvae are one of the main reasons that large black locust trees are uncommon.

The borer larvae are legless, white grubs that taper in diameter from front to back. Thus, if the burrow is chewed large enough for the front of the larva to wriggle through, the back end won't get stuck. Fully grown larvae pupate in the burrows near the surface of the wood, making it easy for the emerging adult to chew its way out into the warm summer air.

Philip L. Nixon, Center for Economic Entomology

Important Subscription Note

For those of you who did not respond to recent subscription renewal notices, this is probably the last issue of this newsletter that you will receive. Nonetheless, if at any time you again wish to receive *Survey Reports*, please send your reques to *Survey Reports*, 607 East Peabody Drive, Champaign, Illinois 61820 (or ca 217-333-6880).

For those of you who did return a subscription renewal form, thank you. W hope to bring you a variety of interestin articles in the years ahead.

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Wingless" Moths

ne females of several related species of oths, including the whitemarked ssock moth, are typically described as ingless. Calling the females wingless is isleading, however, because these oths do have wings, though they are ry small and useless for flight.

A Natural History Survey/University Illinois study of the whitemarked ssock moth that was recently published the *Journal of Morphology* addresses ree basic questions about the so-called ngless females. First, how does the ecies disperse if the female is incapable flight? Second, what is the cause of the ubby wings? Third, what is the biologi- l significance of having stubby wings?

Known by the scientific name *Orgyia ucostigma*, the whitemarked tussock oth, which is common throughout inois, is a member of the family rmantriidae. The females in this family ve been noted by researchers to show a ndency toward flightlessness, and the caterpillars that turn into these moths have been observed to disperse by a phenomenon known as ballooning. After hatching from their eggs, which may be laid on top of the female's coccoon, the caterpillars climb to the tips of branches or leaves, spin loose tufts of silken threads, release their hold on their perch site, and use their silken balloons to carry them aloft on air currents.

The newly hatched caterpillars of the gypsy moth, which is also a member of the family Lymantriidae, likewise exhibit this "ballooning" behavior. Although female gypsy moths in North America have full-sized wings, they seem to be incapable of flight.

Studies of the development of whitemarked tussock moths show that the wings of both females and males develop normally until the onset of adult development. At this time, within the pupal case, most cells in the wings of females quickly degenerate, though their male counterparts maintain normal, functional wings. Researchers believe that the females' wings are genetically programmed to self-destruct through the action of a specific hormone.

The widespread occurrence of winglessness among the Lepidoptera suggests that this sex-limited trait is adaptively significant. In other types of insects—such as aphids, ants, crickets, mosquitoes, and bark beetles—the adult flight muscles of females are known to degenerate as a prelude to egg maturation. Nutritional resources used for flight and muscle maintenance are apparently reallocated to enhance female reproductive success.

In *O. thyellina*, an Asian relative of the whitemarked tussock moth, the female's wing morphology is seasonally variable. Although the summer population of this species has winged females, the females that emerge in the fall are "wingless." The winged females of the summer brood lay smaller eggs than the wingless females that appear in the fall; further-

hough the adult female whitemarked tussock moth appears wingless when viewed from above (left), closer inspection from a side view reveals iny, useless wings (center). In contrast, the adult males of this species have normal, functional wings (right).

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more, the small summer eggs are in a nondiapause state whereas the large, fall eggs are in diapause (dormant). One would expect a correlation between large, diapause eggs in the fall and the funneling of more nutrients from dying cells to developing eggs in wingless females. A seasonal change in the amount of daylight each day may trigger an elevation of a hormone in females that promotes the degeneration of certain tissues and enhances egg maturation.

In the whitemarked tussock moth female, which also has two generations annually, the wings degenerate prior to egg maturation in both generations. Future studies will determine whether hormones in these female moths are involved in the programmed rechanneling of energy and nutrients from wing cells to ovarian development.

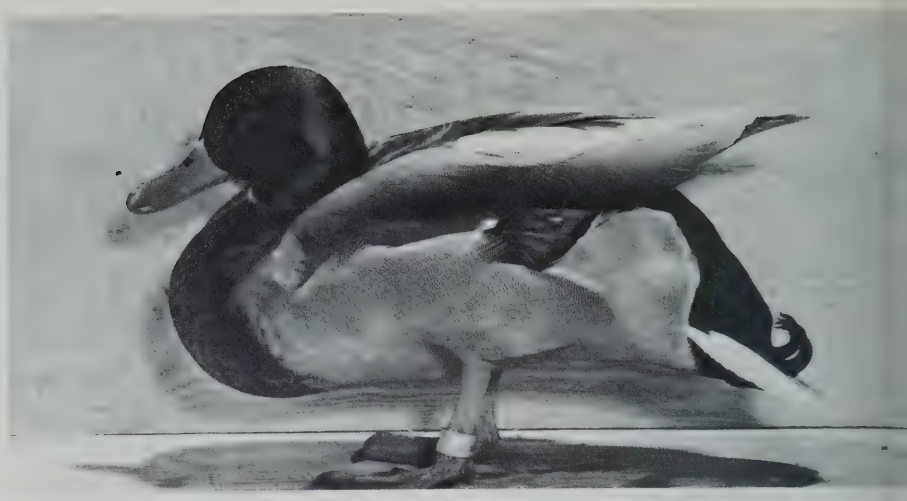
George L. Godfrey, Center for Biodiversity, in cooperation with James B. Nardi, Department of Entomology, University of Illinois

Lead Poisoning in Mallards

Waterfowl contract lead poisoning from the ingestion of spent lead shotgun pellets deposited on lake bottoms and in fields. In severe cases, the birds die after losing up to half of their body weight over a period of several weeks. In the past, an estimated 2–3% of the fall population of waterfowl in North America died each year from lead poisoning.

Lead poisoning from the consumption of hunters' shot also has nonlethal effects on waterfowl. For example, lead exposure causes deleterious biochemical changes in the blood, liver, and brain, with the latter resulting in brain damage. In mallards (*Anas platyrhynchos*), the most heavily hunted species and a principal victim of lead poisoning, the ingestion of lead shot may reduce immunity and increase susceptibility to some infectious diseases.

In response to the problem of lead poisoning in waterfowl, government officials have, effective in 1991, banned the use of lead shot for sport hunting of



One indication of lead poisoning in mallards is wings with a roof-shaped position over the bac

waterfowl in the United States. Nevertheless, the spent shot already deposited over many years in our wetlands continues to jeopardize ducks and geese.

Most waterfowl with ingested lead shot have eaten only one pellet, which disappears from the gizzard in about 20 days and may not kill the animal. Some, however, consume a second pellet soon after the first, and this second pellet may markedly increase the risk of serious harm from lead exposure. Ingestion of a second pellet may be relatively common because waterfowl may spend 150 days on migration and wintering areas that have been subject to heavy hunting use.

Many previous studies of repeat ingestion of lead shot have used game-farm mallards, which may be less sensitive than wild mallards to the sublethal effects of lead poisoning. The physiological effects of redosing wild mallards with lead shot has received little attention. The objective of this study was to investigate the sublethal effects on wild mallards of ingesting a second lead pellet five weeks after the initial dosage.

Sixty-two flightless mallards approximately eight weeks old were livetrapped on Horicon Marsh, Wisconsin, in a nonhunting area. The mallards were placed in an outside holding pen in central Illinois for one year for acclimation and maturation. The holding pen was then divided into three compartments, to which the ducks were randomly assigne Each duck in one group was given only one lead pellet, each in another group ingested two pellets five weeks apart, a a third group received no lead pellets.

Subsequent analysis of the mallards' blood showed higher levels of lead in females than in males that had ingested second pellet. Other studies have likewi shown that females are often affected to greater extent than males, possibly because of differences in food consump tion or body metabolism. Blood lead levels were higher in females after the second lead dose than after the first.

Mallards in the two-dose group also generally had higher concentrations of lead in tissues—such as kidneys and bones—than did one-dose ducks. Ingestion of a second pellet increased lead concentrations in brain and liver more in females than in males. Only tra amounts of lead were detected in breast and gonadal tissue. As in other dosing studies, lead concentrations were highes in bone, intermediate in kidney, and lowest in liver.

The results call attention to the fact that ducks and geese will remain vulner able to the physiological effects of lead poisoning until the lead pellets previous deposited in our wetlands eventually disappear. The recent complete

witchover to nontoxic (steel) shot does ot mean an end to lead poisoning in aterfowl.

tephen P. Havera, Susanne G. Wood, nd Michelle M. Georgi, Center for ildlife Ecology

ybrid Crappies

lthough white and black crappies are nong the most popular sport fishes in e United States, they are difficult to anage in small impoundments because their tendency toward overpopulation d stunted growth. The problem is so mmon and severe that many manage- ent biologists now recommend the clusion of these fishes from ponds and nall impoundments.

We conducted experiments to deter- ine whether the stocking of hybrid appies (produced by interbreeding hite and black crappies) would help to lve this problem. Among the objectives ere to compare the growth of first- neration (F_1) hybrids with that of the rent species and of second-generation $_2$) hybrids; to develop procedures for e production of hybrids; to determine e reproductive potential of the hybrids; assess the capabilities of the F_1 hybrids breed with the parent species; to aluate the hybrids for characteristics ch as resistance to handling and uling, catchability, and physical stinctions; and to field-test hybrid appies in ponds containing established pulations of largemouth bass and other nfishes.

The study produced a number of sitive results. Growth rates of F_1 brids were at least as great as those for her of the parent species, as well as for e F_2 hybrids, in both the first and cond years of growth. In fact, in most ts, growth by hybrids was significantly eater than that by parents. In addition, e viabilities of the F_1 hybrids were nilar to those of their parent species. e also found that the F_1 hybrids had a sex ratio and were capable of oducing a substantial F_2 generation through natural reproduction. When reproduction in ponds was evaluated, the numbers of young produced were greatest for the pure species, intermediate for the F_1's, and lowest for the F_2's. Also, annual sampling for up to seven years of 12 reservoir populations into which F_1 hybrids had been introduced showed that crappie population numbers increased only slightly or not at all.

The F_1 hybrids, which look more like the black parent than the white crappie, can be distinguished from the parent species by subtle differences in body shape and pigmentation. The F_2 hybrids exhibit a wide range of characteristics, as predicted by modern concepts of genetics. We also found that both the F_1 and the black crappie are much more tolerant to handling than the white crappie.

The principal negative finding was the potential for damage to the genetic integrity of endemic black and white crappie populations through backcrossing. In vitro crosses of F_1 hybrids and the parent species resulted in viable offspring. Field work revealed small numbers of natural hybrids, whose identities were confirmed by enzyme analyses, in all four impoundments from which brood fish of both pure species were collected. This finding suggests that low levels of hybridization occur in many waters where both pure species coexist but that the hybrids go unrecognized, perhaps misidentified as black crappie. Although there is no indication at present that the integrities of natural populations of white and black crappies have been impaired, the situation could change following the introduction of large numbers of F_1's into existing crappie populations.

The hybrid fish produced by crossbreeding white and black crappies may have advantages over either parent species.

The F_1 hybrids may offer a viable alternative to stocking the parent species in small impoundments, but all such introductions should be carefully monitored, and additional research is needed to further define the incidence and effects of backcrossing between hybrid and pure stock crappies.

Homer Buck, Center for Aquatic Ecology

Zebra Mussel Update

In the October issue of this newsletter, we reported that zebra mussels had been found for the first time in the Illinois River. Discovering these mussels is disturbing because they lead to both economic and biological problems. By attaching in large dense colonies to underwater objects, such as water intake pipes and boat hulls, zebra mussels can cause great economic damage; by filtering large amounts of water for plankton, these small creatures can devastate the food supply of fish and other species. Zebra mussels were probably introduced into the Great Lakes in 1985 or 1986 when ships from Europe discharged freshwater ballast containing the free-swimming larvae, and they have already become a serious economic pest in the Great Lakes.

The latest evidence suggests that zebra mussels have now spread into the Mississippi River. By early October, when the present issue of this newsletter went to press, zebra mussels had been reported from pools 8, 12, 16, 18, and 26 of the river. Assuming that these findings are confirmed, the mussel now occupies at least 500 miles of the Mississippi.

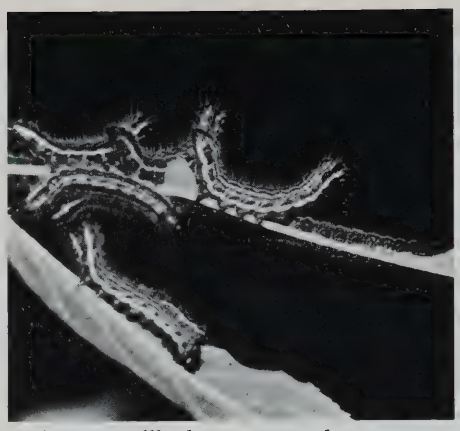
Richard Sparks, Center for Aquatic Ecology

Species Spotlight: Walnut Caterpillar

Walnut, hickory, and pecan trees in Illinois are often home to walnut caterpillars. People usually discover the caterpillars in late summer when wriggling masses of caterpillars sporting soft, white hairs suddenly appear on the trunks of the trees or when the caterpillars almost overnight eat most of the trees' leaves.

Known by the scientific name *Datana intergerrima*, walnut caterpillars are one of several semicommunal caterpillar species in Illinois; they do almost everything in groups. Hatching from a single, layered cluster of eggs, the very small caterpillars line up side by side and graze across the surface of the host leaf. After feeding for a few days, they move a short distance from their original feeding site, molt their skins to allow growth, and then find a leaf where they resume feeding, this time on the edge of the leaf.

Even though they are small, the young caterpillars can be quite conspicuous after the first molt because of their gregariousness and coloration. Clustered on a leaf's edge, the slightly hairy, red-bodied and black-headed caterpillars have been seen bobbing and "dancing" en masse, presumably as a defense against incoming parasitic and predaceous insects, whose wing vibrations the caterpillars can detect with special body hairs or setae.



Walnut caterpillar larvae on a walnut tree

The caterpillars nearly double in size with each successive molt and move increasingly farther away from their feeding site prior to molting. The molting sites of the middle stages are on the branches of the tree, but the caterpillars in the second-to-last larval stage may move all the way from the upper branches to the lower trunk of the tree. They congregate in the same spot on the trunk by, in part, following the silken trails laid down by the caterpillars ahead of them. At this site they continue to spin silk until there is a mass of silk, molting caterpillars, newly molted caterpillars, and shed skins.

Although newly molted caterpillars have bright red heads and are covered with white fluffy hairs, in a short while their heads blacken and their bodies darken. Once this happens, the caterpillars follow their silken trail upward to the feeding area, and massive defoliation may occur. By the time this defoliation is detected by humans, the caterpillars may already have descended the tree to disappear and pupate in the soil and under leaves. After lying dormant in the soil during the winter, the creatures emerge from their cocoons as moths.

George L. Godfrey, Center for Biodiversity

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mmonia in the Illinois River

om 1955 to 1958, several abundant ecies of aquatic insects, snails, and gernail clams practically disappeared m a 100-mile stretch of the Illinois ver. In this reach between Hennepin d the mouth of the Sangamon River, decline of fingernail clams was rticularly dramatic. Peak densities of e fingernail clam species, *Musculium nsversum*, fell from 50,000 per square rd to zero in Peoria Lake and back-ter lakes near Havana. The decline of se clams and other aquatic organisms d drastic effects on the ducks and fish t fed upon the invertebrates. The lesser up, or bluebill, virtually stopped using Illinois River as a major migration te, and the condition and growth of tom-feeding fish declined, lowering value and quantity of commercially portant species such as common carp. The situation changed little into the 1980s despite water quality improve-nts attributable to improved waste atment in the Chicago-Joliet area and oria. The lack of recovery was espe-lly puzzling because the invertebrates rapidly recolonize barren areas, and d populations are present in tributaries. The first clue to explaining the re-onization failure came from studies h fingernail clams at the Survey's er Research Laboratory in Havana. nois River water was treated to remove tain contaminants. The clams survived ny water that had been filtered. Because filtration had removed sedi-nt, the next step was to test the effects ediments from various parts of the er. Two types of tests were developed scientists from the Survey, Southern Illinois University, and Western Illinois University. One test measured the direct effects of untreated sediment on the cilia of clam gills; the other assessed the effects of water extracted from the sediments on the filtering ability of the clams. The cilia on the gills are microscopic hairs that beat in a coordinated pattern to bring oxygenated water and food into the clam and to carry wastes away. Any impairment of ciliary function soon kills the clam. The filtering test determined how rapidly the clams could remove food particles from water.

The tests indicated that the sediments contained a toxic factor that inhibited the cilia and the filtering ability of the clam. They also showed that toxicity increased upstream, peaking near Lockport. The same toxicity pattern was observed with the water flea, which represents an important type of food for fish and waterfowl. In contrast, the sediment stimulated the growth of algae and bacteria, but this was not surprising because of the great physiological differences among plants, bacteria, and animals.

Sediment sampling in the Illinois River

To identify the toxic agent, the investigators then treated and retested water extracted from the sediments. Toxicity greatly decreased when the water was made slightly more acidic or when ammonia was removed. Removal of heavy metals such as zinc and lead had no effect on toxicity. All the evidence thus pointed to ammonia as the culprit, especially because toxicity in all tests correlated highly with the concentration of the un-ionized form of ammonia (the form that exists as a gas dissolved in water rather than as a dissolved ammonium salt), which is toxic to aquatic animals. Because ammonia, composed of nitrogen and hydrogen, is a nutrient for plants and some bacteria, its presence could explain the stimulation of these organisms. Sources of ammonia or nitrogen include sewage plants, industrial plants, and agricultural fields.

Ammonia may be a problem not only for the organisms that fish eat but also for the fishes themselves. Studies by the U.S. Fish and Wildlife Service in 1987, for example, found that water mixed with surface sediments from the Chicago and Des Plaines rivers, tributaries of the Illinois, killed 100% of exposed larval fathead minnows within 24 hours. Surface sediments from Lake Chautauqua, a bottomland lake along the Illinois River at Havana, killed 15% of the test fish in 96 hours; deeper sediments killed 25%. Fish mortality correlated with the concentration of un-ionized ammonia released from the sediment, and both ammonia concentration and fish mortality increased upstream toward Chicago.

Ammonia pollution is not just an Illinois River problem. The U.S. Environ-

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mental Protection Agency identified ammonia as a major sediment-associated toxicant in the lower Fox River and in Green Bay, in Wisconsin. In New York Harbor, ammonia was the only one of 30 contaminants that correlated with toxic effects on glass shrimp.

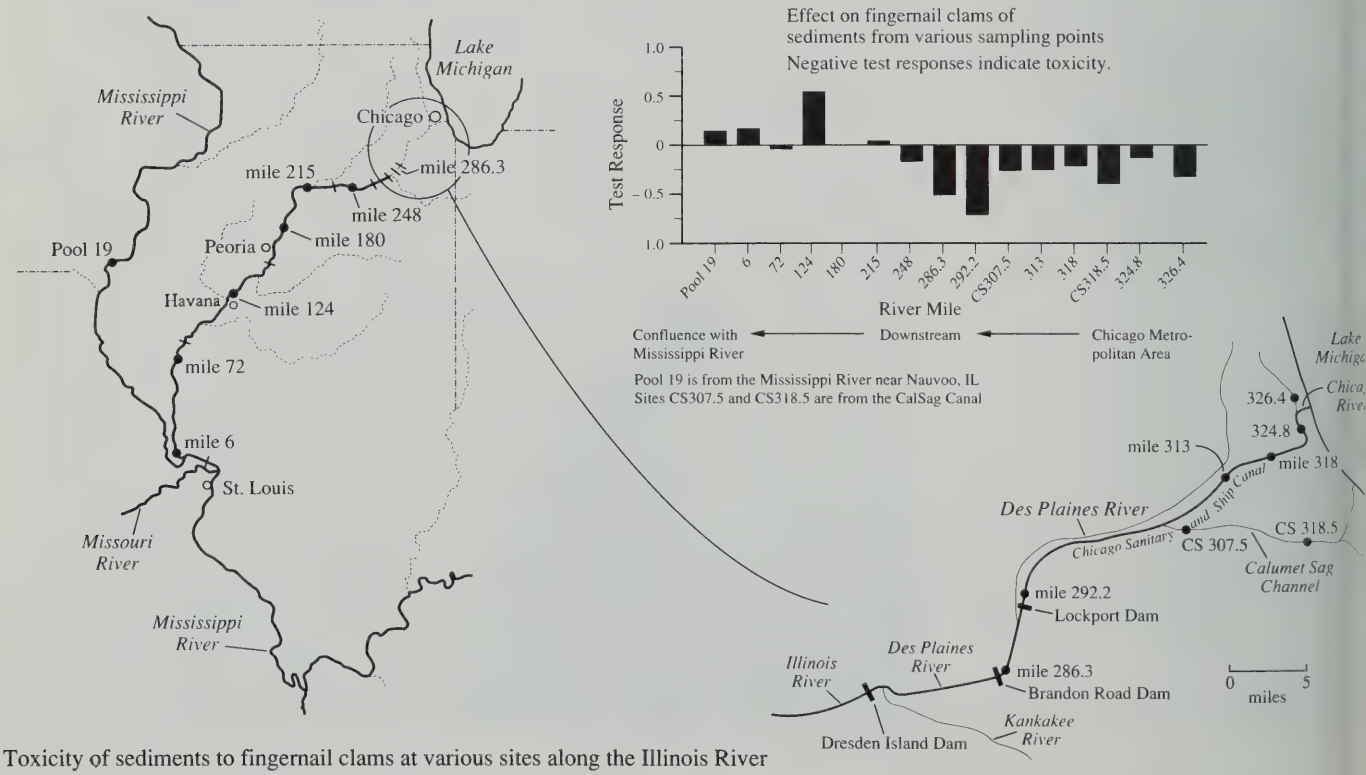
Just as the mystery of the fingernail clam disappearance appeared to have been solved, however, a new complication arose. Several species of fingernail clams, including *M. transversum*, have appeared recently in Chicago area waterways and in the Illinois River at Peoria and Havana. How could clams survive in these supposedly toxic areas? Preliminary evidence suggests four possible answers. First, clams from the upper Illinois may be more resistant to ammonia than clams from the lower Illinois, where the organisms were obtained for all of the early tests. Second, toxicity may have been overestimated in tests where surface and deep layers of sediment were mixed prior to testing because surface layers may be less toxic than deeper layers. Third, toxic episodes may be brief and infrequent, allowing organisms to colonize between episodes. Fourth, the distribution of toxicity in sediments may be extremely patchy, so that healthy organisms are found adjacent to barren areas. If the latter two hypotheses prove true, toxicity in the river has changed recently from a widespread, chronic problem to a more localized or episodic problem. A decline in the toxicity of surface sediments may indicate recent reductions in sources of toxicity, though it is unclear whether the sources are effluents or the deeper layer of sediments or both.

A general recovery in fact does seem to be beginning in the Illinois River. Submersed aquatic plants have appeared for the first time in 30 years in the lower river near Beardstown. Yellow bass and glass shrimp, which use aquatic plants for spawning or cover, have recently reappeared. Largemouth bass are now found throughout the river, and smallmouth bass and sauger are common in several reaches. Recovery of the aquatic vegetation could further reduce ammonia toxicity because the plants remove ammonia as a nutrient.

Aquatic vegetation does not remove ammonia during winter dormancy, however, and fish (and possibly other aquatic animals) are more sensitive to ammonia at cold temperatures. Worse yet, ammonia loading increases during winter because most waste treatment plants do not remove nitrogen; they merely convert it from ammonia to nitrate, and this conversion process stop at cold temperatures.

The sensitivity of animals to ammon varies with life stage and environmenta factors such as temperature and dissolv oxygen. Fluctuations in acidity and temperature of the water likewise contr the proportion of ammonia that exists i the toxic, un-ionized form, so toxicity may vary enormously while the total ammonia concentration remains consta It takes only one brief episode of ammo nia toxicity per year to kill or reduce populations that take many months or years to build up.

The signs of recovery in the river mean that there are now more resource to protect and provide an incentive for accelerating the recovery. The pace and permanence of recovery is still threaten by ammonia, even if the problem turns out to be episodic instead of chronic. It



Toxicity of sediments to fingernail clams at various sites along the Illinois River

mportant to determine whether the mmonia problem is ultimately a nitrogen roblem that could be solved by reducing ie discharge of nitrogen into the river. *ichard E. Sparks, K. Douglas Blodgett, nd Frank S. Dillon, Center for Aquatic cology*

Peregrine Tale: Part 1

epresented by about 20 races world-ide, the peregrine falcon (*Falco eregrinus*) breeds on all continents xcept Antarctica. Fifty years ago, *F. p. natum,* which ranged across North merica, was one race that could be seen Illinois. Early in this century, Illinois osted perhaps a few dozen *anatum* eregrines nesting on cliffs or bluffs ong stretches of the Mississippi and hio rivers. In addition, migrating or andering *anatum* peregrines could, with ck, be encountered anywhere in Illinois uring fall or winter.

Although the *anatum* race survived in e Far West, it disappeared east of the reat Plains by the mid-1970s, a victim f guns, egg collectors, and exposure to e pesticide DDE, which made the birds' gg shells fragile. Consequently, hun-reds of peregrines were bred in captiv-y—many from parental stock of the rctic race, *F. p. tundrius*—and released the Midwest and elsewhere over the ast 15 years. These birds and their escendents can be found living in abitats and areas, such as Chicago, not reviously used by the species.

The combination of arctic genes and ore southern rearing may be responsible r bizarre behaviors. For instance, a 985 news story noted that a falcon bred captivity migrated in the wrong rection and ended up in the Atlantic cean 1,000 miles east of Newfoundland. n October 1990 edition of the *Effingham aily News* reported that a falcon drew attentive crowd downtown by block-g traffic as it lunched on a pigeon.

The arctic race used for breeding—hich is smaller and lighter-colored than e *anatum* race—normally nests in the nd of the midnight sun during the short ctic summer above the tree line in

Dime-sized radio transmitter glued to a falcon tail feather

northern Alaska, the Canadian arctic, and west Greenland. Before the arctic winter begins, young and old begin migrating south toward Central or South America. The daily activities of seven southbound tundra birds, and the passage of four of them through the Chicago area, were discussed in the February and March 1991 issues of this newsletter. The seven study birds were first-year peregrines, scarcely three months old.

Older tundra peregrines, especially males, are rarely banded during fall migration. Autumn captures for 40 years at one hawk-banding station in Wisconsin have shown yearling males outnumbering older males by 30 to 1. This proportion runs contrary to the 1-to-1 ratio predicted by nesting studies showing that an average of two young (one male) per nest survive to migrate.

A chance to study an older bird came in October 1989, when Wisconsin trappers phoned with news that they had just captured and banded a second-year male (about 15 months old) and would keep it overnight if we could get there by morning. We made the deadline, and the bird was released the next morning with a dime-sized radio transmitter glued to a tail feather.

Because adult male sightings are rare, we expected the second-year male to behave in ways that would make him less likely to be seen than first-year peregrines. We anticipated that he would migrate almost every day, traversing the United States quickly and thereby inconspicuously. To our surprise, he lingered six days in Wisconsin, 12 times longer than the half day averaged by first-year birds.

We expected the older bird's hunting to be efficient and quick because it is during this act that peregrines are most often seen. Instead, over the first five days, he averaged 93 minutes of hunting flight daily, almost twice the 53 minutes averaged by the first-year birds we had observed. This result was not only inconsistent with a reduced likelihood of being seen, it was inexplicable on grounds of the older bird's 14-to-2 advantage in months of hunting experience.

Instead of being much less conspicuous than first-year birds, the second-year male was more conspicuous. Because older birds are normally seldom seen, the logical conclusion was that this bird was abnormal; it may have gotten trapped for that very reason. Was he sick? Was he a descendent of captive bred peregrines with mixed behavior because he had *tundrius* genes but was reared in an *anatum* environment? Or was he just a crazy arctic bird with behavior way outside the norm?

At 8:45 a.m. on October 13 he took off and began climbing. The sun had not yet warmed the earth enough to create the bubbles of hot rising air (thermals) hawks use to soar effortlessly to high altitudes, so he had to beat his wings to climb. Deep and rapid wingbeats suggested a strong and healthy bird. From an altitude of about 800 feet, he went into a vertical dive. Although we had never observed younger peregrines hunting this way, high-speed dives are the mark of the species' fame. Watching him plunge toward earth at over 100 miles per hour was beyond ordinary experience, and when he disappeared behind the tree line without slowing, a dead falcon was all we expected to find. However, we soon found him feeding on a bluejay that probably never knew what hit it.

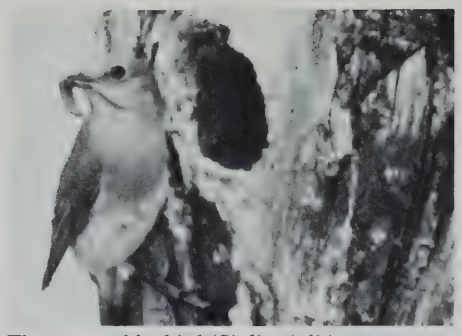
In the next issue of this newsletter, we will describe his travels in Illinois, some unusual behavior, and his untimely death. *William Cochran, Arlo Raim, and Aat in't Veld (visiting scientist), Center for Wildlife Ecology*

Species Spotlight: Eastern Bluebird

The bluebird is a member of the thrush family, Turdidae, which includes the robin. The three species of bluebirds in the continental United States are the mountain, western, and eastern bluebird. The range of the latter species, which is common in Illinois, extends from the Atlantic Coast to the Rocky Mountains and from southern Canada to El Salvador.

The head, back, wings, and tail of the male eastern bluebird are brilliant blue, its throat, breast, and flanks are reddish, and its belly is white. The female's coloration is similar but paler. Birds of both sexes are about 7 inches long and weigh approximately 1 ounce, and their diet consists mainly of insects.

Eastern bluebirds generally migrate to central Illinois in late February or March from southern wintering grounds. Males arrive first, select a nesting area, and then sing to attract a mate. Survey banding studies in west-central Illinois have found that bluebirds tend to stay paired to the same mate throughout a breeding season and to some extent in successive years.



The eastern bluebird (*Sialia sialis*)

The nesting season in central Illinois extends from March into August. The nesting habitat usually includes wooded vegetation in or near open fields, especially grasslands, and nesting cavities are generally less than 7 feet above the ground. Each female typically lays five pale blue eggs during the first of two nesting periods each year and three or four during the second. Nests are built in 4–7 days, eggs are incubated for 13–15 days, and the nestlings, born naked and blind, are fed for 15–17 days before leaving the nest. In autumn, most bluebirds leave Illinois, but some overwinter in the southern part of the state.

Although bluebird survival rates are not precisely known, banded adults typically nest on the Survey's west-central Illinois study area for two or three years, and some have returned for at least five years. Less than 5% of the banded young return, however.

Evidence compiled by the U.S. Fish and Wildlife Service indicates that from 1966 to 1989 bluebird numbers declined 1.5% in Illinois and 29.4% in a Midwestern region including part of Illinois. Populations have suffered from several problems, including competition with other birds for nesting sites and a decrease in nesting habitat because of intensive agriculture. Several states have adopted programs to aid bluebirds, and populations have recently increased in some areas.

The gentle nature and pleasant song of the eastern bluebird have endeared this species to many. The phrase "bluebird of happiness" is truly appropriate for such a splendid, regal bird.

Stephen Havera, Center for Wildlife Ecology

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inois Rice Rats

e name *rat* carries a stigma primarily cause of the habits of the Norway rat d black rat, Old World rodents that ve expanded their ranges worldwide. ving in close association with people, se rats cause massive losses of stored od and extensive property damage, and y spread many diseases, including bonic plague.

Hundreds of other species of small ents commonly called rats live in a iety of natural habitats and have little no contact with humans. The marsh e rat (*Oryzomys palustris*) is one of o native New World rats that live in nois. Interestingly, the marsh rice rat is ed as threatened within the state, and other species, the eastern wood rat, is e-endangered.

Rice rats are largely Neotropical und from Mexico into South America). e marsh rice rat is the only species in genus with an extensive range in the ited States. Its range stretches from reme southeastern Texas north to theastern Kansas, through the south- tern states to Florida, and north along Atlantic coast to Pennsylvania and w Jersey. Although southern Illinois at the northern edge of the species' rent range, during previous periods of rmer climate rice rats lived as far th as Peoria County, where their ains have been identified at an haeological site. The marsh rice rat is iaquatic, inhabiting salt and fresh- er marshes, swamps, and the shores of es and ponds. It is common through- most of its range, although a popula- in the Florida keys (known as the er rice rat) has been proposed for ng as federally endangered. Rela- ly little specific information has been available about the natural history of this species in Illinois.

During the early 1900s, rice rats were known only from Alexander County at the southern tip of Illinois. More recently, rice rats were also found in Franklin, Jackson, Johnson, Massac, Pulaski, Union, Washington, and Williamson counties. Because it was known from so few locations, the species was officially designated as threatened in Illinois in 1978. During 1986–1987, Survey researchers conducted a live-trapping study, funded by the Illinois Endangered Species Protection Board, of 17 southern Illinois counties to determine the current distribution and abundance of the rice rat. In addition, since 1986 other sites with suitable habitat have been sampled as part of environmental assessments performed under contract with the Illinois Department of Transportation. To date, rice rats have been captured at 18 locations in 10 counties. They were caught for the first time in Hamilton, Pope, Saline, and White counties and at new locations in Alexander, Franklin, Jackson, Johnson, Massac, and Williamson counties. The new records indicate that the rice rat occurs farther to the north and east in Illinois than had been thought.

Thus far, more than 150 individual rice rats have been captured. Most of these, however, have been caught during repeated trapping (1987, 1988, 1990, and 1991) at a large wetland complex in Saline County. Although rice rats were numerous near Horseshoe Lake in Alexander County, near Bay Creek in Pope County, and at Worthen Bayou in Jackson County, at most sites where rice rats were found the number of individuals captured was five or fewer. Half of all sites with apparently suitable habitat that have been sampled since 1986 have not been occupied by rice rats.

Changes in *Survey Reports*

This issue inaugurates several changes in *Survey Reports*. We are reducing the frequency of publication from ten to six times per year and increasing the number of pages from four to eight per issue. These changes will reduce our mailing and printing costs while increasing the number of pages published annually.

In addition, we are adding several new features. The current issue, for example, introduces "The Naturalist's Apprentice" (see page 7). Through this regular feature for middle school students, we hope to provide science teachers throughout the state with useful classroom activities on the biological resources of Illinois. Other features will be introduced in future issues.

We hope these changes will enable us to provide more information to more people in a more cost-efficient manner. We welcome your comments.

—The Editor

INSIDE

♦

The marsh rice rat is threatened in Illinois.

Many of southern Illinois' extensive wetlands no longer exist because of surface mining, urban development, highway construction, and, most often, drainage for agriculture. The wetlands that remain are often small and widely scattered and are not capable of supporting large populations of rice rats. Therefore, although its range in Illinois is more extensive than previously thought, the rice rat is not common, and its status as a threatened species in this state appears warranted.

Rice rats have most often been captured in ditches along county or state highways and along the shores of lakes and ponds. The common feature of these sites is the presence of standing water with emergent herbaceous vegetation. Plants typically associated with rice rats are cattails, bulrushes, rushes, spike rushes, and sedges. Rice rats have also been trapped in stands of common reed (also called phragmites), an aggressive wetland species generally considered unsuitable for wildlife. Because of the loss of many natural wetlands, rice rats have to use suitable wetland habitat wherever it is available. The ditches created along highway rights-of-way collect water from precipitation, surface runoff, and agricultural drainage. Standing water may be present long enough for wetland vegetation to become established, and in some areas these ditches may provide the only rice rat habitat.

Additional details about the natural history of the rice rat can be most effectively obtained by radiotelemetry. Tracking individuals fitted with radiocollars can reveal information such as the size of their home ranges, the locations of their nests, their daily activity patterns, and whether they live solitarily or in social groups. The first attempt at radiotracking was made in Saline County in 1991 and produced a few interesting results. A surface nest of finely shredded plant material measuring 11 x 14 inches was found along a roadside ditch 6 feet from the water's edge. Two subadult rice rats, a female and a male, moved 2,200 feet and 1,100 feet, respectively, from the sites at which they were originally captured before dying or shedding the radiocollar. These individuals had been trapped in the ditches along Illinois Route 13; each moved away from the highway rather than crossing it when dispersing. It is hoped that future radiotracking will provide more information that can be used in the protection and management of this native rat.

Joyce E. Hofmann, Center for Biogeographic Information

Nest Association in Fishes

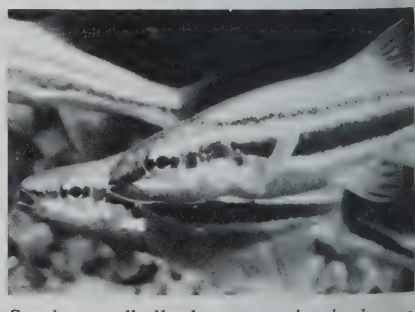
Many species of fish provide for the care of their offspring by getting other kinds of fish to become unwitting foster parents. This practice, termed nest association, involves spawning in the nests of other species and leaving the parental care to the hosts. Although many species that act as nest associates, including many minnows, are capable of building their own nests or of spawning by themselves, some spawn only in the nests of other species.

Hosts of nest associates include sunfish, bass, and nest-building minnows. Male sunfish and bass sweep out depression nests in the substrate. After spawning, the male defends the eggs from predators and fans the eggs to improve oxygenation and to keep the eggs free from silt. Eggs do not survive without this parental care. Males remain with the nest until the eggs have hatched and the fry disperse. Minnow nests range from simple pits excavated in the substrate to elaborate gravel-mound nests. After spawning, some male minnows cover the eggs, a practice that increases offspring survival. Males defend the nest from potential egg predators but may stay over the nest only as long as spawning opportunities exist.

The various hosts differ not only in the type and degree of parental care they provide but also in the number of associate species they attract. Usually only one associate species uses the nest of sunfish and bass, which live in quiet waters. In most cases the associates, which seldom number over 100 individuals, drop their spawned eggs into the host nest from several inches above. Associate eggs blend in with those of the host.

In contrast to sunfish and bass, most nest-building minnows live in flowing water. Nests of some species may attract as many as eight species of associates, and associate individuals may number in the thousands.

Nest associates obviously benefit from the parental care of the host, but what effect does nest association have on the host? Are nest associates parasites, lowering the reproductive success of the hosts, or is nest association a mutualistic relationship in which both associate and host benefit? If associates prevent the host from spawning, prey on the brood (eggs and fry) of the host, or cause an increase in egg predation due to greater conspicuousness, then their presence would reduce the reproductive success of the host. On the other hand, hosts could benefit from nest association if predation on their own offspring is reduced by the presence of the other species' offspring.



Southern redbelly dace spawning in the nest of a minnow. Photo by William Roston.

My research focused on determining
nature of the relationship between
st and nest associate. Experiments were
nducted using green sunfish as hosts
d redfin shiners as nest associates.
ese species are common in Illinois and
wn together in late spring. This two-
cies relationship is probably the
nplest nest associate/host system.
pically from six to approximately 100
le redfin shiners defend territories over
fish nests during spawning. Male
fish do not attempt to drive the redfin
ners away but do defend their nests
m potential egg predators. The primary
od predators are juvenile sunfish,
ich are often observed entering
ccupied nests and eating eggs. Redfin
ners have not been observed preying
eggs.

In the experiments, conducted at the
tural Resources Studies Annex pond
in Champaign, the green sunfish were
wed to spawn with and without redfin
ners. Juvenile sunfish were present to
as brood predators. Fry from these
ts were collected upon hatching and
nted.

Sunfish that had nest associates had
her reproductive success, in terms of
number of fry, than those that did not.
e results show that, at least in this
ple system, hosts benefit from having
t associates spawn in their nests.
cause of the dilution of host offspring
those of associates, predators take
er host offspring in nests with
ociates.

Although these results indicate a
tualistic relationship between host and
t associate, in more complex situations
t association may be detrimental to the
t. Some studies, for example, have
wn a high degree of predation on the
od of the host by nest associates.
ure studies will aid in understanding
evolution of this strategy and the
ure of the relationships of the species
olved.

rol E. Johnston, Center for
diversity

Corn Rootworm Research

Western and northern corn rootworms are the most serious insect pests of nonrotated corn in the Midwest. Adults lay the vast majority of their eggs in the soil of cornfields during August and early September, and the eggs lie dormant until hatching in the spring. Very few eggs are laid in other crops. Because rootworm larvae cannot survive on roots of crops such as soybeans, alfalfa, or wheat, crop rotation is recommended to manage these pests. In fields where corn is grown year after year, soil insecticides are typically applied to protect roots from rootworm feeding.

Although crop rotation usually prevents trouble with rootworms, instances of rootworm damage to corn grown in rotation with other crops have been reported. Some researchers have suggested that northern corn rootworm infestations in first-year corn are explained by oviposition in fields planted in crops other than corn the preceding season. Other studies have failed to support this hypothesis. An earlier study in Illinois found that oviposition in soybeans and damage to corn the following season were negligible where soybean fields were essentially free from volunteer corn plants; damage did not reach serious levels even when corn was planted after weedy soybeans.

An alternate explanation for damage in first-year corn is that northern corn rootworm eggs may undergo prolonged diapause—that is, eggs pass through two or more winters before hatching. In 1965, a Minnesota researcher was the first to document that northern corn rootworm eggs (from Minnesota) could remain in diapause for more than one winter, but he concluded that the percentage of eggs with this trait was too small to be economically important.

South Dakota researchers reported in 1984, however, that about 40% of the eggs from a population in their state underwent prolonged diapause. Larvae from this many eggs could potentially cause significant damage to corn after a one-year rotation with another crop. Indeed, reports of corn rootworm damage in corn planted after soybeans became more prevalent in the early 1980s, particularly in the northwestern region of the Corn Belt (Iowa, Minnesota, and South Dakota).

Northern corn rootworm beetle.

After receiving reports of corn rootworm damage in corn after soybeans in Illinois, we initiated laboratory studies and an extensive field survey to determine whether the prolonged diapause trait was present in Illinois rootworm populations. In laboratory studies, we found that northern corn rootworm egg diapause ranged from one to four years for populations of eggs from east-central Illinois. In addition, the percentage of eggs that hatched following prolonged diapause ranged from 13.9% for eggs from northwestern Illinois to 51.3% for those from east-central Illinois. The percentage of eggs undergoing prolonged diapause was greatest in areas of Illinois where crop rotation is common, suggesting that crop rotation can provide strong selection pressure for eggs to remain in diapause for more than one year.

Surveys were conducted from 1986 through 1989 in 1,100 fields in 35 counties in northern and central Illinois. The incidence of corn rootworm larval damage in corn after soybeans was greatest in the central, northeastern, and eastern regions. In these areas, annual rotation of corn with soybeans predominates and northern corn rootworm populations are larger than in other parts of the state. Nevertheless, only 1.7% of the fields surveyed and 6.2% of the plants examined had been damaged severely enough to warrant the possible use of soil insecticides.

Although prolonged diapause has now been positively confirmed in Illinois, the results of our surveys indicate that this trait will rarely cause economic damage in corn after soybeans. Annual rotation of corn with nonhost crops, such as soybeans, will continue to be the most reliable management strategy for corn rootworms, and the use of a soil insecticide in this rotation scheme will continue to be discouraged.

Eli Levine, Hassan Oloumi-Sadeghi, Kevin Steffey, Michael Gray, and Donald Kuhlman, Center for Economic Entomology

A Peregrine Tale: Part Two

Although half the southbound migrants of the arctic race of the peregrine falcon (*Falco peregrinus tundrius*) are more than a year old, Wisconsin banding records show that these older birds are much less likely than first-year peregrines to be trapped or seen. Therefore, when an older bird was caught and radiotagged in Wisconsin in October 1989, we expected to observe behavior that would render it significantly less noticeable than the three-month-old birds we had previously tracked. To our surprise, as we reported in the previous issue of this newsletter, this 15-month-old male's behavior was highly conspicuous during his six-day stay in Wisconsin, and we concluded that he was abnormal.

After five days of balmy fall weather, a cold front moved across Wisconsin on the morning of October 16, 1989. Though it is typical for first-year birds to migrate 250 miles per day under such conditions, the second-year male averaged only 60 miles per day during its four-day trip from Sheboygan, Wisconsin, to near Clinton, Illinois. Then on October 20 he flew east, still under the influence of the cold front, which by then had brought light snow and westerly winds. After he left Sheboygan, his major flights were directly downwind and short, suggestive of a weak bird with barely enough energy to retreat before the cold. First-year tundra birds not only migrate faster but also do so in specific innately determined directions that are only occasionally and coincidentally directly downwind.

Ailing male peregrine allowed photographer to approach within arm's length.

The idea of failing health was supported by a decline in the number and success of hunting flights after October 16 (see Table 1). Previously, his hunting statistics had been similar to those of the first-year birds, which averaged 11 hunting flights and one kill per day.

In the afternoon of October 20, he flew from Clinton to a farmyard 1/2 mile south of DeLand High School. We found him crouched down between two rows of stacked firewood by a barn; he did not flush when we peered down at him. Toward evening we watched him creep through the grass and hide under a brush pile behind the farmhouse. During the night he was killed and partially devoured by an unknown predator, probably a skunk or raccoon.

Analyses of his brain tissue revealed levels of toxic contaminants such as polychlorinated biphenyls (PCBs) and the pesticide DDE that would be high for humans, and the amount of mercury in his muscles seemed excessive. Without comparative analyses of tissue from a healthy peregrine, however, we were uncertain of the significance of these values.

We finally obtained comparative tissue analyses in October 1991, when a first-year female peregrine we had been observing was electrocuted on a power pole 1/2 mile south of Kankakee High School. Although her tendency to perch on power poles and home TV antennas, as well as her leisurely three-day pace from Sheboygan to Kankakee, marked her as significantly different from other young peregrines, she was healthy, as evidenced by her strong, fast flight the previous evening and her consistent taking of prey.

Analyses of brain and muscle tissu from the healthy female peregrine revealed essentially no PCBs, a DDE level less than 1% of that in the ailing male, and only one-fourth as much mercury as in the male (see Table 2). Pa of these differences could be attributabl to the difference in the birds' ages. The male had considerably more time to accumulate the contaminants, all of which remain in the body for a long tim

A major part of the differences in concentrations could be related to differences in diet in various locales. Unlike the healthy female, whose norm migration carried her away from Lake Michigan less than two days after we radiotagged her, the male lingered alon the lake for at least six days. His last tw meals were shorebirds, one taken at water's edge on the public beach at Sheboygan. Because lake contaminants

Table 1. October hunting record of ailing second-year male peregrine.

Date	# Flights	# Prey
11	4	1 (unknown)
12	10	none
13	12	1 (blue jay)
14	8	1 (dove)
15	7	1 (sandpiper)
16	7	1 (sandpiper)
17	5	none
18	5	none
19	3	none
20	2	none

Table 2. Toxic contaminant concentrations brain tissue of healthy first-year female and ailing second-year male peregrine.

	Concentration (ppm)	
Contaminant	Healthy female	Ailing m
Heptachlor epoxide	<0.0001	0.0607
Dieldrin	<0.0001	0.255
DDE	0.0390	4.78
PCBs*	<0.0001	9.71

*Polychlorinated biphenyls. Mercury conce trations in muscle were 0.274 ppm in the healthy female and 1.07 ppm in the sick ma

nclude all of those found in excess in the ale, we surmise that his consumption of ese shorebirds and other lakeshore raging prey led to contaminant accumu- tion sufficient to cause the lethargy that ntributed directly to his death.

In the past, humans and peregrines ared relative safety at the top of the od chain. Nowadays the top may be ore dangerous for us both.

Finally, we would like to end this eregrine tale with a note of thanks. We eeply appreciate the cooperation, spitality, and enthusiasm of the staff of e Cedar Grove and Little Suamico rnithological stations in Wisconsin, here the falcons we studied were apped, banded, and radiotagged.

illiam Cochran, Susanne Wood, Arlo aim, and Aat in't Veld (visiting scien- st), Center for Wildlife Ecology

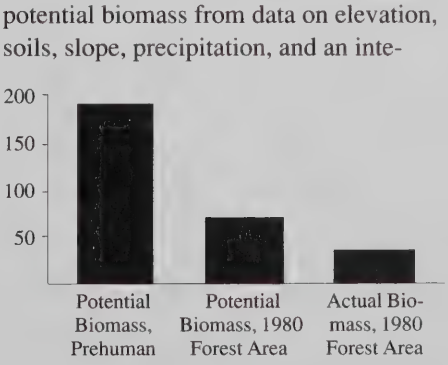
ssessing Tropical Forests

ropical forests are crucial to the well- eing of the planet. In addition to arboring most of the Earth's biotic iversity, they are important to world- ide climate patterns because of their volvement in the global cycling of arbon. The multitudinous trees of the opical forest have a major impact on tmospheric concentrations of carbon ioxide, a gas that contributes to global arming through the greenhouse effect, ecause trees absorb this gas as they grow nd release it as they decompose or burn.

Scientists at the Survey and the niversity of Illinois Department of orestry are using sophisticated computer chniques to estimate changes over time the amount of aboveground living tree ssue in the tropical forests of South and outheast Asia, including India, Vietnam, hailand, and Burma. Funded by the U.S. epartment of Energy, this work to stimate the forests' "biomass" is part of multi-institutional effort to assess the et amount of carbon dioxide entering the tmosphere due to tropical land-use anges. These changes include degrada- on of intact forests through selective gging and other human activities as well as outright conversion of forestland to nonforest uses, such as agriculture. In the past, researchers estimated that land-use changes contribute somewhere between 10 and 50% as much carbon to the atmosphere as does the burning of fossil fuels, such as coal and gasoline.

Our initial studies centered on peninsular Malaysia, as a case study area, because very good forest inventory and land-use data were available for this region for two points in time. We found that from 1972 to 1982, 17% of the forestland in this area was converted to nonforest uses, mostly from forestland that had been previously logged. In the same interval, an estimated 28% of the forest biomass was lost. Therefore, estimation of the carbon flux from land conversion alone would have grossly underestimated the amount of carbon actually entering the atmosphere. By using our computerized geographic information system (GIS) to analyze the data, we discovered that most conversions were occurring near the edges of intact forests and that biomass degradation was most pronounced in locations where more forest fragmentation had occurred (more perimeter per unit area, and thus more accessibility for humans).

Because forest and land-use information is much more scarce for the rest of South and Southeast Asia, we adopted a different approach to estimate forest biomass for the entire region. Initially, we estimated the amount of forest biomass that would be present across the subcontinent if no humans were present. To do this, we used GIS techniques to model potential biomass from data on elevation, soils, slope, precipitation, and an integrated climate index, called Weck's climate index. Forest inventories were found for a few locations across the region, allowing us to calibrate the GIS model of potential forest biomass. Total potential forest biomass for nine countries was estimated at approximately 192 billion tons in the absence of humans.



Estimates of potential and actual forest biomass in South and Southeast Asia, in billions of tons.

We then "cookie-cut" the potential forest biomass map with a map of forest locations for 1980; this gave us a map of the potential biomass occurring on locations still in forest in 1980. The total potential biomass estimate for these remaining forests was only about 69 billion tons, or 36% of our estimate for the total forest biomass in the absence of humans. Therefore, 64% of the potential biomass had by 1980 been lost to outright land conversion to nonforest.

Finally, our computer models of forests in 1980 were adjusted to account for the degradation, or "thinning out," of forests by human activities, such as the removal of selected trees for firewood. The resulting estimate of aboveground forest biomass present in 1980 was about 33 billion tons. This represents 48% of the potential biomass for 1980 forested lands and only 17% of the potential biomass in the absence of humans. These data can be used to estimate total annual flux of carbon dioxide into the atmosphere from this region.

The effort to estimate existing and potential forest biomass is now continuing for Central and South America and will eventually include tropical Africa. The overall effort should substantially reduce the uncertainty concerning the contribution of land-use change to alterations in atmospheric concentrations of carbon dioxide. This method of estimating forest biomass has been adopted by the United Nations Food and Agriculture Organization for their 1990 assessment of tropical forest resources; we continue to work closely with this international agency headquartered in Rome.

Louis Iverson and Anantha Prasad, Center for Biodiversity, in cooperation with Sandra Brown, University of Illinois Department of Forestry

Species Spotlight

Crawford's Sedge

Although sedges are important members of many Midwest plant communities, the diversity of these grasslike species is not widely recognized. *Carex*, the largest genus in the sedge family, contains about 150 species, making it the largest genus of flowering plants in Illinois.

The recent discovery that the sedge *Carex crawfordii*, or Crawford's sedge, lives in Illinois is noteworthy because the range of this species is generally limited to northern regions with cold climates, including Canada and northern Michigan, Wisconsin, and Minnesota. Except for isolated populations on mountaintops in the southern Appalachians, this species had not previously been found south of the "tension zone," a band crossing through central Wisconsin marking the southern range limits of many northern plants and the northern range limits of some southern prairie-forest species.

The discovery of a single population of Crawford's sedge in Illinois about 130 miles south of its southern extent in Wisconsin is another piece of the biological puzzle that links our contemporary native vegetation to the glacial history of our state. This northern species evidently spread south to Illinois and the high mountains of Tennessee during the last ice age, when climatic belts in effect moved south as the glaciers advanced, creating cooler climates in central and southern North America. When the climate warmed, the sedge could no longer live in most parts of Illinois or more southern regions, but some populations survived in suitable habitats (on mountaintops, for example) as "relicts."

Seeds of *Carex crawfordii* (Crawford's sedge) are grouped in spikelets. Photo by John Taft.

The populations existing today in Illinoi and the southern Appalachians are not only relicts of a cooler climate but also survivors of the xerothermic period, an interval of hot, dry weather following th last glacial advance that played a signifi cant role in the formation of many Illino native plant communities.

The Illinois population of Crawford sedge is in a Lake County marsh threatened by highway development. This wetland has been farmed, apparently during dry springs, when low soil moisture allows cultivation. Many wetland species survive in soil seed bank during unfavorable conditions such as dr weather. The ability of this and other wetland species to survive for a few year as seeds in the soil offers opportunities for wetland restoration. Much biological information, such as that contained in the distribution patterns of species relicts, could be lost with the development of these remaining wetland habitats.

John Taft, Center for Biogeographic Information

Teacher's Guide to "The Naturalist's Apprentice" (facing page)

"The Naturalist's Apprentice" presents educational activities for middle school students. Teachers are invited to photocopy this feature and "Species Spotlight" for classroom use.

OBJECTIVE: This installment of "The Naturalist's Apprentice" demonstrates that plants are unevenly distributed across the landscape and examines reasons behind plant distribution.

SKILLS/PROCESSES: deduction, map plotting, map reading

VOCABULARY: disjunct, distribution, endangered, range, relict, threatened

MATERIALS: copies of "The Naturalist's Apprentice" and "Species Spotlight"

COMMENTS: The preceding "Species Spotlight" provides background material for this exercise. The distribution of Crawford's sedge shows how various factors affect where plants grow. In general, plants are adapted to a type of environment that meets at least their minimal needs for moisture, sunlight, nutrients, and other essentials. Other factors—such as long-term climatic changes—also affect distribution and often cause populations of a single species to be widely separated.

PROCEDURE: **1.** Have students read about Crawford's sedge and discuss it as a class. Students may also research the sedge family (Cyperaceae) for additional background material on this interesting group of plants.

2. Distribute copies of "The Naturalist's Apprentice." Students may begin the exercise by labeling each state on the U.S. map o by labeling only those states in each plant's distribution.

3. Have students construct a distribution map for each species based on the geographic descriptions given. Students color the states or portions of states in which each plant occurs. Different colors can be used for each plant.

EVALUATION: Discuss the following questions in class.

1. What factor or obstacle appears to limit the westward distribution of the American beech? (*It appears to stop when it reaches the Midwestern great plains or prairies*).

2. How can the current distribution of reniform sullivantia be explained? (*Glaciers that invaded the Midwest missed certain parts, allowing the species to persist in some locations. When the glaciers melted, the plants were left isolated in suitable habitats. This is called a relict species.*)

3. What is an explanation for the distribution of Garber's sedge? (*It prefers the climate and soils around the Great Lakes and has not spread to other suitable habitats, if any exist.*)

Plant Biogeography: Why Is This Plant Here and Not There?

he preceding "Species Spotlight" on rawford's sedge shows that plants are ot uniformly distributed across the ndscape. To illustrate the distribution of everal other plants in the United States, bel the appropriate states on the map elow (you may need to abbreviate the ates' names) and then color the states or arts of states in which each plant lives. se a different color to represent the istribution of each species.

eniform Sullivantia—This endangered pecies of flowering plant lives on moist iff faces in areas that were never covered y glaciers. It has two disjunct popula-ons. One is in northwestern Illinois, ortheastern Iowa, and southeastern Minnesota, and the other is along the Mississippi River above St. Louis with a fingerlike extension into south-central Missouri. This species once had a much wider distribution.

Garber's Sedge—This small grasslike species is found only along the shores of the Great Lakes and is considered threatened in Minnesota, Illinois, Wisconsin, and Ohio.

American Beech—The gray-barked American beech is found in every state east of the Mississippi River. In Florida, however, this tree lives only in the panhandle, and in Illinois it is found only along the Wabash and Ohio rivers, along the Mississippi River up to St. Louis, and in the extreme northeastern part of the state. Furthermore, it is not found in extreme southeastern North Carolina and northeastern South Carolina, the eastern part of Wisconsin that borders Lake Michigan, and extreme western Michigan (the western part of the Upper Peninsula, which is connected to Wisconsin). West of the Mississippi River, American beech occurs in both eastern and western Louisiana, southeast Texas, southwest and northeast Arkansas, and southeast Missouri. The population in Texas, western Louisiana, and southwestern Arkansas is separated from the rest of the species by the Mississippi River floodplain and is considered disjunct.

"The Naturalist's Apprentice" presents educational activities for middle school students. It is published by the Illinois Natural History Survey, Champaign.

New Publication on Tree Care

A new publication on tree care is available from the Survey. Authored by scientists at the Survey and the University of Illinois, it consists of an extensive list of documents, audiovisual aids, workshops, and other sources of information on tree health care management. The list was compiled from inquiries to university extension and publication offices, state agriculture and forestry departments, the U.S. Forest Service, arboretums, and other organizations and businesses.

Each of the 2,000 citations, alphabetized by author, includes the title of the source material and information for ordering, including the cost. A subject index identifies information sources for particular topics. Titled *A Compendium of Information on Tree Health Care, Including Diseases, Insects, Weeds, and Cultural Practices,* Special Publication 12 costs $4 and can be ordered from Distribution Center, Illinois Natural History Survey, 607 East Peabody Drive, Champaign, IL 61820.

New Poster and Workbook

Illinois' Living Alphabet is a new 22" x 34" coloring poster available from the Survey. It comes with a teacher workbook, which describes the Illinois organisms pictured and suggests related classroom activities. One poster and workbook cost 50 cents; sets of 30 are $10.

Photography Workshop

The Survey's Michael Jeffords and Susan Post will present a nature photography workshop on Saturday and Sunday, April 11–12. The field portion of the workshop takes place in southern Illinois. The $50 registration fee includes the cost of transportation, accommodations for two nights at Dixon Springs, and meals. For more information, please write to Michael Jeffords at 607 East Peabody Drive, Champaign, IL 61820, or call 217-333-5986.

Illinois' Living Alphabet is 22" x 34".

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orest Fragmentation and Deer

though farmland deer were virtually terminated early in this century, tricted legal hunting and careful rturing of transplanted deer decades o have enabled populations to recover. er have adjusted well to the intensively med landscapes in Illinois and are now ndant throughout the state, even ere forests make up less than 5% of landscape. Studies of deer captured in nois and marked with ear tags, plastic lars, or radio transmitters have vided insights into how deer adjust to ing in areas where forest cover is rce and fragmented, increasing posure of deer to hunters and other ential dangers.

Trends in the demographics of deer Illinois are the result of three processes: (1) increasing deer numbers on ge refuges; (2) stable to slowly reasing numbers in large, hunted ests; and (3) fluctuating numbers of r within small woodlots and bottomd forests where deer populations are quently decimated. Males die at higher s than females because of hunter ference for antlered males and because males' seasonal movements are ensive, usually exceeding the bounds of most refuges. Females are derharvested, and deer numbers have sequently been steadily increasing.

The flow of deer from high- to low-sity areas (from refuges and larger ests to woodlots and small bottomland ests) occurs in spring for both sexes vns and yearling females) and in the for yearling males. The young deer dispersing (moving permanently away m a birth site) or migrating (moving y temporarily) to these low-density areas to take advantage of the available food and cover. In northern and east-central Illinois, about half of the fawns and about 20% of the yearling females disperse in the spring to new habitats from the scattered sites used as winter cover. These dispersal movements average nearly 50 kilometers (31 miles) and occur between late April and early June each year. Another 20% or so of the yearling males disperse in the fall, apparently the result of breeding activities. Another 20% of yearling and older females become migrators, leaving winter sites in the spring and returning to the same winter site each fall. Migration distances from winter sites average less than 15 kilometers (9 miles). Except for female migrators, most adults of both sexes select a home range before they are 15 months old and occupy the same area throughout life.

The current patterns of local, temporary extinctions and recolonizations observed in east-central Illinois resemble those on islands, with distances from refuges, size and composition of forest fragments, and predation (primarily hunting) dictating deer abundance. Migrations (females) and dispersals (both sexes) allow deer to reoccupy marginal habitats such as flood-prone bottomland

Although deer are amazingly tolerant of human activities, they must have some cover that provides safe sanctuary during daylight hours.

INSIDE

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forests and small woodlots where fall and winter mortality is high; in summer, these habitats provide relatively risk-free birth sites for females and rich feeding areas for males building body reserves for the coming breeding season.

Females maximize the probability of survival for themselves and their fawns through continual use of the same birth sites, either by remaining sedentary throughout life and sharing a home range with related females, migrating to the same site each spring, or dispersing to a new site and remaining on this site throughout life. Males also benefit from remaining sedentary after about 15 months because this allows them to rise more rapidly in the social hierarchy and become a successful breeder.

The availability of suitable wintering sites and the existence of forested corridors connecting these sites with habitats used spring through fall by dispersing and migrating deer remain the keys to continued successful occupancy of the intensively farmed Midwest. Retention of existing upland forests is particularly important because bottomland forests are often flooded and rendered inaccessible to deer for extended periods. Although deer are amazingly tolerant of human activities, they must have some cover that provides safe sanctuary during daylight hours. Such sites are becoming rare in Illinois.

Charles M. Nixon, Center for Wildlife Ecology

Climate and Species Migration

Human activities are increasing atmospheric concentrations of carbon dioxide and other gases that contribute to global warming through the greenhouse effect. Burning coal or gasoline, for example, releases carbon dioxide into the atmosphere, and clearing forestland decreases the number of trees available to absorb this gas.

Computer models incorporating a predicted doubling of carbon dioxide levels during the next century forecast a decrease in summer rainfall and an increase in average temperatures of 1 to 4°C (2 to 7°F) in Illinois, with detrimental effects on agriculture. The likelihood of drought-related crop failure will increase substantially, and economically important crop plants will be increasingly threatened by the northward expansion of pest insects and weeds that are now restricted to warmer, more southern regions.

With global warming, the ranges of species that prefer cooler temperatures, such as beech trees (foreground, left), will shift northward. Beech trees and some other species now found in Illinois may eventually disappear from the state.

An additional and often less appreciated problem is how future warming will affect distributions of native species. For a clue to how distributions will be altered, we can look at the historical record. A warming of North America by approximately 2°C (4°F) after the most recent glaciation (8,000–15,000 years ago) led to massive changes in the natural distributions of plants and animals. Vegetation in central Illinois changed from boreal forest to prairie.

The best predictions for the next century suggest that most species will need to move northward between 250 and 800 kilometers (about 150 to 500 miles) to respond to climatic warming. Illinois in a good geographic position to study these range shifts because the state encompasses several biome boundaries. On the eastern edge of the prairie, we expect an expansion of prairie flora wit drying conditions. We also predict a northward retreat of colder-climate species whose ranges now dip into northern Illinois. Species such as beech paper birch, and perhaps even sugar maple could be extirpated from Illinois their ranges shift to the north. Finally, many of the diverse woodland plants of southern Illinois—species characteristic of the southeastern United States—are expected to expand their ranges into central and northern Illinois.

Although warmer winters will plea many people, the warmer climate will also adversely affect biological diversit because plants are limited in how fast they can respond to climatic warming. During past climatic changes, trees wer able to expand their ranges an average only 50 kilometers (about 30 miles) per century. Woodland understory herbs an nonvascular plants may respond much more slowly. To keep pace with predict climate changes, plant species would have to move northward 10 times faster than they did after the last glacial advance.

Migration of tree species in the nex century is actually likely to be slower than in the past because migration through modern fragmented forests—th is, forests that have been carved up into small, isolated units—is slower than tha through pristine habitat. To evaluate the effects of forest fragmentation on tree migration rates, we have used computer simulations to model past rates of speci migration through an undisturbed habita and then adjusted for habitat loss, whic reduces the availability of colonization sites. The results suggest that future tre migration will be as much as a 10 times slower than previous migrations. Thus, species will probably be unable to adju their ranges quickly enough to compen sate for future warming. It may even be

fficult to detect whether plants are sponding to warming through range anges at all.

This lack of migration response will particularly acute in agricultural states e Illinois where natural habitats are w relatively rare. The failure to spond to climatic warming through gration is likely to place some species peril of extinction.

ark Schwartz, Center for Biodiversity

ompetition among Larval Fish

many Illinois reservoirs, gizzard shad e the most abundant prey for sport fish ch as walleye and largemouth bass. zzard shad also compete for food with ner small fish. For example, both zzard shad and bluegill, another sport h, consume only zooplankton (minute imals) after hatching in the spring as vae. Competition with gizzard shad for oplankton during this period may slow owth and reduce the number of bluegill t survive.

To examine these species interactions more closely, we took reservoir samples and conducted laboratory tank experiments at the Survey's Kaskaskia Biological Station, located at the upper end of Lake Shelbyville in central Illinois. At six reservoir sampling stations, larval fish and zooplankton populations were monitored weekly from April through September, 1988–1991.

The number of larval gizzard shad in Lake Shelbyville was extremely high throughout the spring and peaked in early June. About one week later, zooplankton abundance declined dramatically. Larval gizzard shad thus seemed to reduce substantially the amount of food available to some other fish, including larval bluegill.

The density of larval bluegill was much lower than that of gizzard shad (2 versus 118 fish per cubic meter) and peaked two weeks later. Although bluegill growth was not related to the number of gizzard shad, bluegill survival was greatest when gizzard shad abundance was declining and zooplankton populations were recovering. Growth and survival of gizzard shad were highest when gizzard shad densities were lowest.

We conducted laboratory experiments in 750-liter fiberglass tanks. Natural zooplankton populations were pumped directly from Lake Shelbyville into the tanks, into which we introduced either low or high numbers of larval bluegill and gizzard shad. Tanks contained one or both species.

As in Lake Shelbyville, gizzard shad growth and survival in the tanks were influenced by larval fish density, as well as by the amount of zooplankton. Some species of zooplankton influenced growth and survival more than others. The quantity of copepod nauplii, for example, was most strongly related to gizzard shad survival rates. The tank experiments also confirmed that gizzard shad have no effect on bluegill growth but do affect larval bluegill survival.

The results of our studies demonstrate the important role that gizzard shad play in reservoir communities. Future studies will examine the effects of gizzard shad on populations of zooplankton and predator fish, including many sport fish species. Much of our future ability to effectively manage reservoir fish communities may depend on our understanding of the effects of gizzard shad on these systems.

Michael T. Welker, David H. Wahl, and Clay L. Pierce, Center for Aquatic Ecology

mpling tank experiments at the Kaskaskia Biological Station. Natural zooplankton popula-ns were pumped directly from Lake Shelbyville into the tanks, into which researchers roduced larval bluegill and gizzard shad.

Improving a Natural Pesticide

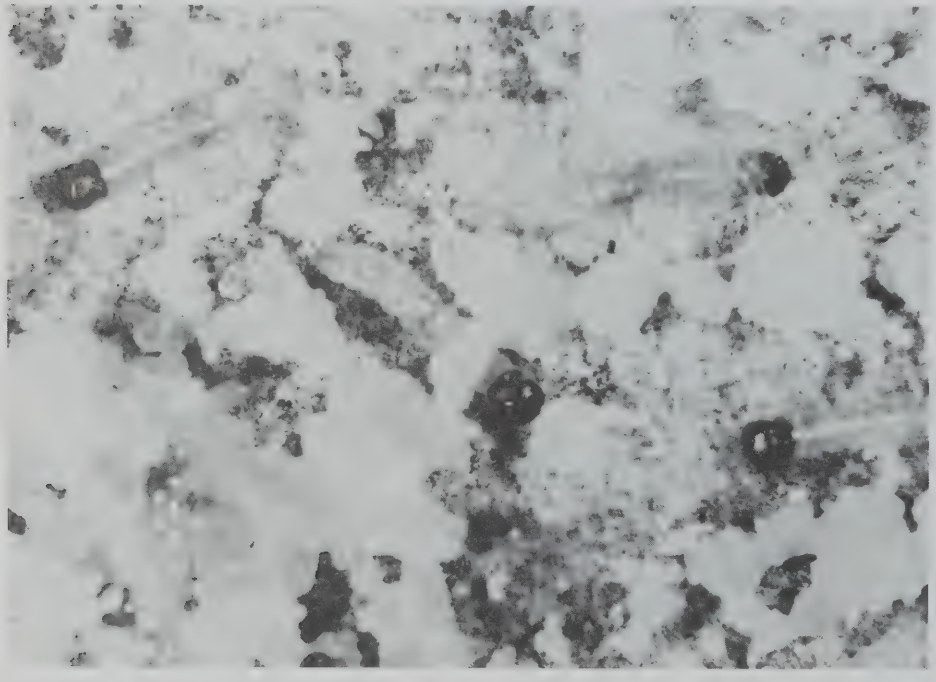
Microscopic organisms that cause diseases in insects can dramatically reduce populations of insect pests in agricultural fields. Unfortunately for the farmer, however, outbreaks of these diseases usually occur after crops have been seriously damaged. Efforts to mass-produce these microbes for field release to stimulate infections earlier in the population cycle have resulted in the

commercial production of the bacterium *Bacillus thuringiensis*.

For more than 20 years, *B. thuringiensis* strains have been used to control larvae of two major groups of insect pests. The bacterium is very specific to these pests and does not affect the beneficial insects in the field. Certain aspects of the bacterium's field performance, however, have hampered widespread acceptance by farmers. Although it is extremely effective immediately after application, the bacterium loses this activity quickly when it is exposed to sunlight, especially ultraviolet rays. At the National Center for Agricultural Utilization Research in Peoria, scientists are collaborating with Survey entomologists to extend the activity of *B. thuringiensis*.

The method developed for protecting the bacterium in the field involves the use of cornstarch, an inexpensive and readily available surplus commodity. Cooking the starch causes gelation. If the cooking is interrupted and the water removed, a dry, free-flowing powder can be recovered. This powder is then dispersible in cold water, much like instant pudding. When this modified starch, called pregelatinized starch, is added to water containing *B. thuringiensis* and other additives (50% starch, 50% water), a gelatinous, sticky mass forms. After a few hours, the starch goes through chemical reactions that make it rubbery. At this point, the mass may be ground up into granules that can be applied with common on-farm applicators and that readily filter down to the feeding sites of susceptible insect pests, such as European corn borers. Because the bacterium exists throughout the starch granule, it will not wash off as does commercially formulated *B. thuringiensis*.

Our experiments have shown that additives to the starch granules can provide additional protection for the bacterium. For instance, the addition of dyes that absorb ultraviolet light increases the longevity of the bacterium. Also, some additives induce corn borers to feed preferentially on the granules. In greenhouse and field tests, granules that contained one-fourth the recommended dose of the bacterium controlled corn borers if the granules also contained the commercial feeding stimulant COAX. Without COAX, higher doses were required for similar control.



European corn borer larvae feeding on granules made from pregelatinized cornstarch.

Another *B. thuringiensis* formulatio that holds promise employs low concentrations of pregelatinized starch. When starch and powdered sugar are mixed together and then added along with the bacterium to water in low amounts (abo 4% solids), the solution can be sprayed through nozzles onto agricultural fields. As the solution dries, it forms a thin film on the crops and thus entraps the bacterium and other additives on the leaf surface. In greenhouse tests, under mild simulated rainfall, this formulation retained its activity for 14 days whereas bacterium without starch was quickly washed off. This type of formulation could be used on vegetables and other crops whose insect pests are susceptible to *B. thuringiensis*.

Michael R. McGuire, Center for Economic Entomology (affiliate)

Lead Poisoning of Diving Ducks

Ingestion of spent lead shot deposited on lake bottoms and in fields often leads to lead poisoning in waterfowl. The result can be illness and disability or death. Annual mortality from lead poisoning ha been estimated at 2–3% of the fall waterfowl population in North America.

Although the use of lead shot for sport hunting of waterfowl was outlawed in 1991, lead poisoning from the ingestion of shot continues to be a problem because of the large amount of spent lead shot remaining in our wetlands. In the past, more than 6,000 metric tons of lead shot was deposited annually in wetlands by American hunters. In the October issue of this newsletter, we discussed the hazard this remaining shot poses to mallards. This article focuses on bay diving ducks.

Currently, low continental populations of canvasbacks (*Aythya valisineria*), ring-necked ducks (*A. collaris*), and lesser scaups (*A. affinis*) are causing concern. Previous studies showed that these diving ducks ingest shot at a high rate during the autumn hunting season, but little has been known about shot

sser scaups were live-trapped during spring on Keokuk Pool for determination of the prevalences of ingested shot and elevated blood lead ncentrations. Blood samples were taken from the brachial vein and tested for lead content.

nsumption rates or blood lead param-
ers during spring migration, a critical
ysiological period shortly before the
set of nesting. A study by me and
chard M. Whitton of the Illinois
epartment of Conservation—who
nducted these studies as part of his
aduate research at Western Illinois
iversity—sought to determine the
evalence of ingested shot and elevated
ood lead concentrations in diving ducks
Keokuk Pool during the spring
grations of 1986 and 1987.

Keokuk Pool of the Mississippi
ver extends 74.5 kilometers (about 46
les) north from Lock and Dam 19 at
okuk, Iowa, and consists of approxi-
tely 11,000 hectares (about 27,170
es) of open water habitat. It has been
scribed as the "most important inland
a for migrating diving ducks in North
nerica." Its high use by diving ducks
been attributed to the abundance of
nthic invertebrates, especially finger-
l clams (*Sphaerium transversum*).
nual spring peak population counts of
nvasbacks, lesser scaups, and ring-
cked ducks on Keokuk Pool have
eraged about 81,000, 140,000, and
000, respectively; annual autumn
unts have been similar.

Prevalences of ingested shotgun pellets (both lead and steel) during spring 1985 and 1986 were higher than in autumn 1985 for lesser scaups (29% versus 5%) and ring-necked ducks (56% versus 11%). The 29% prevalence of ingested shot for lesser scaups in spring at Keokuk Pool was higher than values reported in other studies. Although not documented by our study, some of the ingested shot we found could also have been acquired by the birds on southern wintering areas because ingested shot stays in the gizzard for about 20 days before being eliminated. The high prevalence of shot in canvasbacks in spring 1986 (35%) at Keokuk Pool was comparable to that reported during the winter of 1987 (27%) for Catahoula Lake, Louisiana, an important wintering area for diving ducks in the Mississippi Flyway.

Lead ingestion rates of diving ducks are generally higher than those of other waterfowl. Waterfowl consume shot during feeding, and species, such as diving ducks, that feed most actively on the bottom of shot-laden lakes are most prone to accidental shot consumption.

Blood lead levels greater than 0.20 parts per million (ppm) are considered above normal for waterfowl, and levels greater than 0.50 ppm are toxic. For ducks live-trapped during spring, above-normal and toxic blood lead levels were found in 53 and 16% of canvasbacks, 39 and 8% of lesser scaups, and 71 and 35% of ring-necked ducks; average blood concentrations were 0.31, 0.22, and 0.55 ppm, respectively. Male lesser scaups had higher average blood lead concentrations (0.23 ppm) than females (0.20 ppm). In addition, male lesser scaups that had toxic blood lead levels weighed less than those that had lower concentrations in the blood.

Because populations of canvasbacks, lesser scaups, and ring-necked ducks are now at precariously low levels, it is especially important that these species not be subjected to lead poisoning prior to the nesting season. Lead shot deposited in wetlands hosting migrating and wintering waterfowl remains a potential source of toxicity until natural processes, management techniques, or the birds themselves serving as biological filters reduce the availability of the spent shot.

Stephen P. Havera, Center for Wildlife Ecology

Species Spotlight

Eastern Massasauga

The eastern massasauga is found throughout Illinois, except in the southern tip of the state.

The eastern massasauga is one of four species of poisonous snakes found in Illinois and one of two native rattlesnakes. In the 1800s, eastern massasaugas were common over the northern four-fifths of the state, and young men killed them to establish a reputation for courage and enterprise. Some farm boys slaughtered two or three dozen in a year.

As prairie marshes were drained and more and more land came under cultivation, the number and extent of these rattlesnakes decreased dramatically in Illinois. They are still found, however, in widely scattered colonies throughout their original range. Prairie marshes and old fields with a heavy bluegrass cover are the preferred habitats.

The eastern massasauga, *Sistrurus catenatus catenatus*, is 2 to 3 feet long and is usually gray-brown with a pattern of brown or black squares on its back and sides; the belly is mottled with black and yellow. It prefers to eat small mammals, especially rodents.

This snake becomes sexually mature during its third year of life. The female goes into winter hibernation carrying developing eggs, which are fertilized during mating the following spring. Each female bears 5–14 young in late summer; the 6-inch-long young are extruded one at a time, a minute or two apart.

The newborn snakes are on their own, and mortality is high. They soon starve if they can't find food they can swallow (very small rodents, reptiles, or amphibians). The young are also preyed upon by other animals, and many die during the first winter because they don't hibernate deep enough in the ground.

Rattlesnakes are born with venom, fangs, and a single tiny rattle segment called a button. A new rattle is added each time the snake molts, or sheds its skin, when growing. Adults typically have a string of four to six rattles, which are made up of keratin (the same material found in humans' fingernails). Shaken as a warning to possible enemies, the rattles sound like maracas or buzzing cicadas.

During a recent periodical cicada outbreak, the search for the noisy cicada revealed not insects but an eastern massasauga, much to the surprise of the scientist and the snake!

Very few people in Illinois have be bitten by the eastern massasauga, and th bite is not deadly, though victims requir hospitalization. Indeed, massasaugas in the wild usually avoid people. If cornered, a massasauga may coil its body and vibrate its rattle. It will, however, usually prefer to retreat than to strike. The massasauga is only trying to defend itself from intruders of superior size. Unfortunately, the first human a rattlesnake encounters is often its last.

Teacher's Guide to "The Naturalist's Apprentice" (facing page)

"The Naturalist's Apprentice" presents educational activities for middle school students. Teachers are invited to photocopy this feature and "Species Spotlight" for classroom use.

OBJECTIVE: to understand that snakes and other reptiles are fascinating and important parts of the natural world

SKILLS/PROCESSES: visual discrimination, classification

VOCABULARY: reptile, herpetology, class

MATERIALS: copies of "The Naturalist's Apprentice"

COMMENTS: Herpetology is the study of reptiles and amphibians. In this exercise we will concentrate on the class Reptilia, including snakes, lizards, and turtles. Although to most people the sight of a snake or lizard leads to a negative or fearful response, the vast majority of Illinois reptiles are harmless to humans and actually provide a service by feeding on rodents and insects. The four species of poisonous snakes found in Illinois are all uncommon, and few people have bee bitten by them. Nonetheless, anyone who spends time out of doors should learn to recognize and avoid them. An excellent reference for this exercise is *The Amphibians and Reptiles of Illinois*, written by Philip W. Smith and published by the Natural History Survey in 1961.

PROCEDURE: Distribute copies of "The Naturalist's Apprentice" and have students follow the instructions. You might have students list the reptile groups on the chalkboard.

EVALUATION: Assign students a single species of reptile and have them write a short paragraph describing it (life cycl food preferences, habitat, etc.). The paragraph should include statement on why this animal should be protected, or why it should not. Discuss these paragraphs as a class.

Reptiles in Hiding: Can You Find the Names of Your Reptilian Neighbors?

nakes, lizards, and turtles are reptiles. ne names of 23 of the 59 species of ptiles that live in Illinois are hidden in e puzzle below. Find and circle the mes, then write them in the appropriate aces to the right. The names of snakes e printed horizontally; the names of rtles, vertically; and those of lizards, agonally. Beware! Some names are ritten backward. The words *snake*, *ard*, and *turtle* are also in the puzzle.

eptile names hidden in puzzle:

- igator snapper
- rn
- stern fence
- stern milk
- ound skink
- idland water
- inted
- airie ringneck
- t
- ugh green
- nooth softshell
- estern fox
- coachwhip
- cottonmouth
- eastern glass
- false map
- hognose
- ornate box
- plains garter
- queen
- red-eared slider
- six-lined racerunner
- stinkpot

Snakes (12)

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Lizards (4)

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Turtles (7)

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L	R	I	N	G	N	E	C	X	K	R	E	T	A	W	D	N	A	L	D	I	M	R	U	C	N	D	E
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Identification of Fungi

About 70% of plant diseases are caused by fungi, including molds and mildews. Effective control of these diseases requires correct identification of the disease-causing agents. The conventional procedure for identifying fungi involves isolation, culturing, and microscopic observation, a process that may take several days to a few weeks. To identify fungi more quickly, we are using molecular biology techniques to search for genetic traits characteristic of particular fungal pathogens. Two Survey research projects in this area are described below.

The genus *Pythium* includes some ubiquitous plant fungal pathogens that cause damping-off, seed rot, and root rot diseases of many agricultural and ornamental crops. Identifying *Pythium* species is difficult because the morphological features are not easily observed and because some species are distinguished based on minor quantitative differences that are influenced by environmental conditions. To facilitate prompt identification, we are analyzing fungal genetic material to find traits characteristic of several important *Pythium* species. Species-specific DNA fragments have been identified and may be used to differentiate these *Pythium* species.

Roots of rice plant infected by *Pythium* sp. (left) compared to those of a healthy plant.

In another study, we are using molecular biology techniques to identify various anastomosis groups (AGs) of fungi classified together under a single species name, *Rhizoctonia solani*. This complex species, which causes diseases on agricultural crops, encompasses at least 10 AGs, and strains of each group associate with certain plant species. For instance, AG-3 is mainly a pathogen of potatoes whereas many AG-2 strains are associated with root diseases of crucifers such as cabbage. A recent study showed that AG-2 is also pathogenic to soybean.

Identifying AGs usually requires the time-consuming pairing of unknown strains with characterized tester strains of each AG. Using new techniques, we have identified "genetic fingerprints" that can be used to differentiate eight AGs. These fingerprints not only enable us to assign *R. solani* strains to groups but also provide evidence about the genetic diversity within this species.

Weidong Chen, Center for Biodiversity, in cooperation with Zonglin Liu and James B. Sinclair, Department of Plant Pathology, University of Illinois

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avigation Dams and Their nvironmental Effects

avigation dams on the Illinois and pper Mississippi rivers have signifi-ntly altered natural water level patterns. some areas, for example, operation of e dams has led to permanent inundation the floodplain, in contrast to the tural cycle of flooding and drying out. is alteration of the normal water gime has adversely affected biological mmunities associated with these rivers.

Ranging from 7 to 49 feet tall, the e navigation dams on the Illinois River ere are two additional dams on the terways that connect the Illinois River Lake Michigan) and the 28 on the pper Mississippi River impound the ainstem channel to maintain a depth of least 9 feet during low river flow. Most vigation dams on the two rivers employ tes that can be raised completely out of water (roller gates or tainter gates) or t fold into the river bottom (Chanoine ckets). The gates thus pass sediments th little obstruction.

Although navigation dams have little no effect on water levels during major ods (because the gates are out of the ter and many of the dams also have ed-crest spillways that are overtopped higher flows), at intermediate flows the tes or wickets can be partially opened control water levels. The goal has been maintain water depths for navigation ile curtailing the extent and duration of oding. This operating strategy has nimized the amount of land and mber of easements the government has d to buy because of additional flooding e to operation of the dams.

Deciding whether to raise or lower gates or wickets is based on antici-

Lock and Dam 26 on the Mississippi River. Photo by Max Schnorf.

pated inflow and changes in pool storage. The objective is to maintain target water levels at a control point located either at the dam or at a point midway to the next dam upstream. If the water level is rising at the control point, the gates are opened to increase flow and maintain the control elevation; if the level is falling, the gates are closed.

If the control point is at the dam, the floodplain near the dam is permanently inundated at all river stages. Also, water levels do not increase at the dam as flow increases, until all gates are out of the water. Water levels upstream do increase, in proportion to their distance from the dam. If the control point is at midreach, water levels near the dam are drawn down in the spring as flow increases—just the opposite of the natural pattern!

In the Illinois and Upper Mississippi rivers, the reaches between dams typically have a downstream, impounded portion and an upstream portion of about equal length that retains the floodplains and islands characteristic of the undisturbed river. The entire reach between the dams is commonly called a "pool."

Altering the natural water level pattern is detrimental to the plants and animals that use the floodplain and its associated lakes, backwaters, and wetlands because the normal water regime performs important biological functions. Normally, spring flooding expands backwaters and floodplain lakes, thereby providing spawning areas and nurseries for fish as well as feeding areas

INSIDE

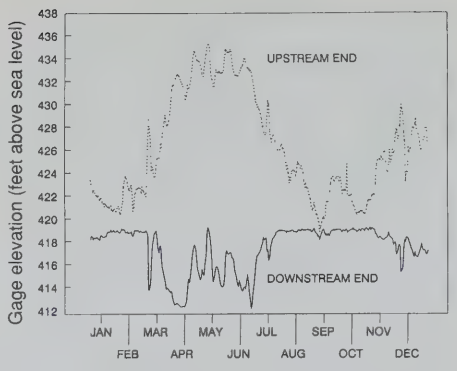
♦

for migratory waterbirds. Biological productivity is enhanced (this is termed the "floodpulse advantage") by a variety of processes, including the release of nutrients from newly flooded soils as the water advances across the floodplain.

Likewise, the annual drying out of the floodplain in summer benefits many species. Whereas decomposition and recycling of nutrients and organic matter proceed relatively slowly in an aquatic environment, wood and leaf litter break down rapidly in well-oxygenated, moist environments, as on floodplains during low-flow periods. Soils become compacted during the drying process and are less susceptible to resuspension by boat- or wind-generated waves when they are subsequently reflooded, especially if they are anchored by plant roots.

Low, stable water levels in summer in the backwaters and floodplain lakes encourage the growth of submersed aquatic plants, at least in those lakes where the sediments are firm enough to provide roothold and the water is not excessively turbid because of suspended sediment. The plants provide food for animals either directly, through consumption by muskrats and herbivorous species of ducks and turtles, or indirectly, by forming detritus that is consumed by invertebrates and some fishes. The plants also shelter invertebrates and juvenile fishes. Furthermore, when floodplain lakes and pools shrink in summer, the fish they contain are concentrated into a decreasing volume of shallow water. The fish are then more easily caught by herons and egrets that locate their rookeries near floodplain lakes and pools. Because fishes that use floodplains and backwaters can rapidly rebuild their populations, annual losses to predation or desiccation are recouped as long as sufficient adults survive in deepwater refuges to breed again in spring.

Water levels that are too stable can lead to overpopulation of fish and stunted growth. The normal decline of water levels in the summer forces many juvenile fish out of protective plant beds along the shore and into the jaws of



Water level fluctuations in 1991 in Pool 26 of the Mississippi River, just upstream of St. Louis. The pattern at the upstream end is a typical natural floodpulse: a spring flood, low summer water levels, and a little flood in autumn. The pattern 40 miles downstream is essentially the reverse: the water level drops during the spring and autumn floods and is higher during low flows.

predators, including larger fish. Without the fall in water levels, a larger number of smaller fish compete with each other for food. A common problem in many reservoirs is that an initial burst of good fishing, stimulated by the permanent inundation of the floodplain and expansion of aquatic habitat, is followed by a decline in productivity and in the abundance of large fish. These long-term trends can be reversed to some degree by instituting annual water level fluctuations modeled after the natural regime.

The "little flood" that normally occurs on the Illinois and Upper Mississippi rivers in autumn provides migrating waterbirds access to the seeds, tubers, and leaves produced during the summer. Many of these birds prefer to dabble, wade, or dive in shallow water rather than forage on land. Waterfowl managers often try to mimic the natural water regime by erecting low levees on the floodplain and using pumps, if necessary, to raise water levels in autumn.

Water level manipulations at the dams draw water down at the wrong time of year for plants and animals. The watery sediments do not dry out during spring rains and become as well oxygenated as they might during a more natural summer drawdown. They also do not become colonized with moist-soil plants because the water is drawn down before most of these plants are ready to germinate. Even if moist-soil plants do germinate, they are soon drowned by rising water levels during what should be their normal summer growing season.

Operation of the dams also leads to unnaturally dramatic fluctuations in wate levels. When the water level begins to fall, the decline is accelerated as gates ar closed upstream to store water to maintain depths for navigation. With extra water being held up at each dam, the water deficit increases downstream from dam to dam. This accelerated decline in water level may adversely affect organisms, such as larval fishes, that may be prematurely swept out of backwaters. Th water level fluctuations are especially severe at the downstream end (the Illinoi end) of the chain of navigation pools in the Mississippi River because the drawdowns are greater and the gates are moved in larger increments (4-foot increments at Dam 26, for example).

Several changes in management of the navigation pools could benefit the living natural resources of the Illinois an Upper Mississippi rivers. Although half the floodplain along the Illinois River an the Upper Mississippi River bordering Illinois has been leveed and drained, primarily for agriculture, the remainder should be used to store and convey flooc and to benefit fish and wildlife. This management strategy should *save* money in the long term because regular floodin would discourage or prevent building of structures on the floodplain that are at risk during major floods. Flood damage in the Illinois River floodplain from 197 to 1986 was so bad that two or more counties were declared disaster areas by the President in 1979, 1982, 1983, 1985, and 1986, and total damage costs were over $200 million.

Attention should also be given to improving land-use practices in the drainage basin (soil conservation, revegetation of riparian zones, and restoration of wetlands and channelized streams) to reduce flood peaks and delivery of sediment to the main river.

he sediment settles in the backwaters nd floodplain, reducing wildlife habitat nd flood storage capacity. This sediment ccumulation has been exacerbated by ediment inputs well above natural levels.

To modify the operation of the dams benefit fish and wildlife, the Army orps of Engineers could in some cases mply operate the dams to use flood asements already purchased. In other ases, mid-pool control points might be ifted to downstream control points and dditional flood easements purchased to ompensate landowners for any increase bove natural levels in the frequency of ooding. Such easements could be urchased if Congress authorized and nded the Corps to operate the dams for nvironmental purposes as well as for avigation. Even within the existing ongressional authorization, it might be ossible to adjust the gates in the dams in ner increments and in accordance with a an that makes the water regime more nducive to fish and wildlife.

ichard Sparks, Center for Aquatic cology (with information provided by eter Bayley, Charles Theiling, and aniel Wilcox)

quatic Worms Of Illinois

e are all familiar with common rthworms, particularly after a heavy in when they are flooded from their rrows onto sidewalks, streets, and iveways. Less well known are the worms inhabiting aquatic and semi-aquatic habitats, including springs, seeps, swamps, marshes, ponds, lakes, reservoirs, streams, and large river systems. Just as earthworms play an important role in terrestrial ecology (by breaking up organic materials, improving aeration and moisture penetration, increasing the amount of water the soil can hold, and enhancing soil fertility), so too are worms an important component of benthic communities. Aquatic worms have been collected from nearly every aquatic habitat, ranging in water quality from pristine streams to rivers and harbors grossly polluted by domestic, agricultural, and industrial effluents.

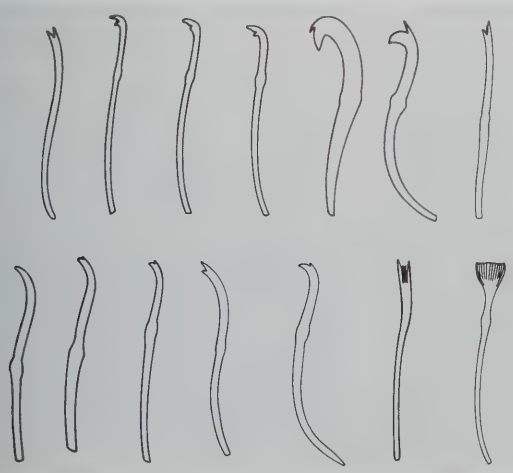
Although much is known of the systematics, distribution, and ecology of mammals, birds, fishes, and many other species in Illinois, the knowledge of aquatic worms is limited. Aquatic worms are classified in the phylum Annelida, which comprises six classes, including four found in Illinois: Aphanoneura, Branchiobdellida, Hirudinea, and Oligochaeta.

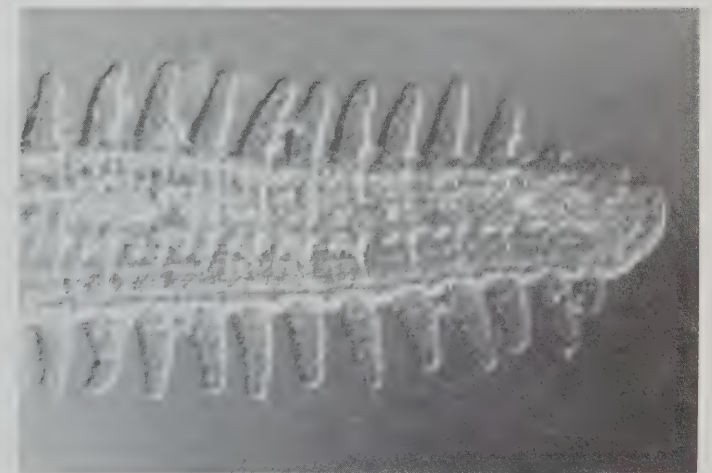
The aphanoneurans, or aeolosomatid worms, are extremely small (0.5 to 10 mm) and delicate. They can be distinguished from other wormlike animals by their color spots, type of hairs, and suction-like feeding behavior. These small worms are often collected from decaying leaves and other plant material in ponds and lakes. Of the 11 species of aeolosomatid worms found in North America, at least three have been collected in Illinois.

Branchiobdellidans are small, white aquatic worms with minute jaws within the mouth cavity and a posterior sucker. They are called crayfish worms because they are collected only from the outside of and from within the gill cavities of crayfishes. Of the 101 species of branchiobdellidans known to occur in North America, nine are found in Illinois.

The Hirudinea, or leeches, are highly specialized worms distinguished from other groups by the presence of a sucker on both the anterior and posterior ends and by having 34 body segments. Most species feed mainly on aquatic macroinvertebrates, including other worms and insects. A few species may reside as parasites on the outside of and on the gills of fishes, and one or two species may be found associated with the nasal passages and eyes of waterfowl. A few leech species may feed on carrion, and others may feed on the blood of amphibians and reptiles. Leeches in Illinois present little if any medical threat to humans, even though they may occasionally attach to a swimmer's leg or foot. Of the 64 freshwater species of leeches in North America, 32 have been collected from Illinois habitats.

The class Oligochaeta represents the most diverse and widely distributed group of worms in terrestrial and freshwater habitats in North America. Aquatic oligochaetes are commonly collected





quatic worms are often distinguished by the type of chaetae, or hairs, they possess (various types of chaetae are shown at left). A few species of uatic worms have gills (shown at right on posterior end of *Branchiura sowerbyi*).

from benthic substrates, from submersed and emergent aquatic and semiaquatic vegetation, and from a variety of other substrates, both natural and man-made. Among the 175 known species of freshwater oligochaetes in North America, 83 are found in Illinois; three terrestrial species also are commonly collected in aquatic and semiaquatic habitats in the state. In contrast, only 29 of 142 species of earthworms found in North America have been collected in Illinois.

The Survey's annelid collection currently consists of approximately 200,000 identified and 50,000 unidentified specimens, including members of the Aphanoneura, Branchiobdellida, Hirudinea, and terrestrial and aquatic Oligochaeta. Most of the identified material consists of permanent slide mounts; unidentified material consists of permanent slide mounts and unmounted specimens stored in alcohol. Although the specimens have been collected from around the world, the vast majority are from Illinois, and most have been collected during the past 18 years. A computer compilation of annelids that have been collected and identified is under way. This database can be searched and sorted by entry criteria such as species, county, water body, location, collector, and date.

An annotated checklist of the aquatic Annelida in Illinois was recently published by this author in the *Transactions of the Illinois State Academy of Science*. That paper represents the first comprehensive review of these species in Illinois. A literature review, current classification scheme, and checklist of names were provided for 15 families, 71 genera, and 130 species of freshwater Annelida in the state. Eight species were reported as new records for Illinois.
Mark J. Wetzel, Center for Biogeographic Information

Corn Borer Study and Control

The first recorded observation of the European corn borer, *Ostrinia nubilalis* Hubner, in Illinois occurred in 1939 in Lake County; two years later, the first severe infestation was found in Kankakee County. In slightly more than 50 years since its introduction into Illinois, this insect (first identified in the United States in 1917 near Boston) has become the preeminent pest of corn throughout the state. Yield losses attributed to the European corn borer in Illinois annually exceed $50 million.

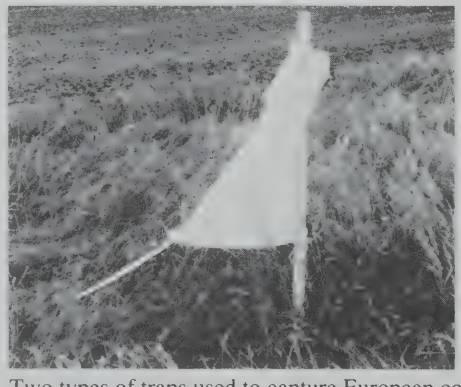
Since 1943, preharvest surveys for European corn borers have been conducted in approximately one-third of the counties in Illinois. Recent surveys have been performed cooperatively by staff from the Natural History Survey, University of Illinois, and the Cooperative Extension Service. Although earlier researchers tried to use survey data to predict serious infestations the following year, recent surveys have been used primarily to assess yield losses. Monitoring techniques that sample the adult stage (moth) have proved more useful for predicting future infestations.

To attract European corn borer moths for sampling, researchers have baited traps with sex pheromones, which are chemicals emitted by the female insects to attract mates. Over the past several years, Extension entomologists have used these traps to help predict phenological events in the life cycle of this pest. For instance, studies have shown that European corn borer larvae are generally beginning to bore into the corn stalk after 350 degree-days have accumulated (base 50°F) from an initial capture of spring moths in pheromone traps. (Degree-days are the number of degrees above a specified base level of the average daily temperature.) This information is useful to corn producers because once tunnelin occurs, rescue treatments are no longer effective. During the growing season, degree-day accumulations along with management recommendations are reported in the *Pest Management & Cro Development Bulletin*, a weekly publication by the Cooperative Extension Service.

In some states, such as New York, different races of European corn borer moths respond to different blends of pheromone. Although the races of moth in New York are morphologically the same, they differ from each other in certain characteristics, such as host plan range and their sexual pheromone communication systems.

Until recently, it was not well understood how European corn borer moths in Illinois would respond to a pheromone blend other than the Iowa strain, the particular form of pheromone produced by most of these moths in Illinois. Because of the economic importance of this pest, it is essential tha monitoring techniques be well understoo and optimized.

In 1991, an experiment was conducted at several locations in Illinois to test the relative usefulness of Iowa and New York strain pheromones for attracting European corn borer moths and to evaluate the comparative effectiveness o two pheromone trap designs (aerial wate pan and nylon mesh cone). Traps baited



Two types of traps used to capture European corn borer moths: nylon mesh cone and aerial water pan.

th the Iowa strain attracted signifi-
ntly more moths than those with New
ork pheromone lures or with no
eromone bait. The two trap designs
ere about equally effective in northern
d central Illinois, but in southern
inois, the cone trap was more efficient
capturing moths. Results from this
udy will be useful to crop consultants,
e seed industry, producers, and ento-
ologists seeking to refine monitoring
ategies for this key insect.
E. Gray, H. Oloumi-Sadeghi, and K.L.
ffey, Center for Economic Entomology

eopold Award to Sanderson

en C. Sanderson, retired director of the
nter for Wildlife Ecology, received the
92 Aldo Leopold Memorial Award at
e formal banquet of the 57th North
nerican Wildlife and Natural Resources
nference on March 31 in Charlotte,
rth Carolina. The award is the highest
nor bestowed by The Wildlife Society
d is presented annually for distin-
ished service to wildlife conservation.
cipients are people who have achieved
tional and international prominence,
e stalwarts of the wildlife profession.

Dr. Sanderson received a master's
gree in field zoology from the Univer-
y of Missouri-Columbia and a doctor-
in animal science (reproductive
ysiology) from the University of
nois. He was employed by the Survey
1955, promoted to the rank of Profes-
nal Scientist in 1963, and made
ector of the wildlife research unit in
64. He also held professorships at the
iversity of Illinois and Southern
nois University. In 1989, he was
omoted to the distinguished rank of
ncipal Scientist, a level that only four
ers have held in the 135-year history
the Survey.

Dr. Sanderson's primary area of
pertise is mammalogy, a field in which
is highly respected nationally and
ernationally. He is probably the
rld's leading authority on the biology
d ecology of the raccoon. His thesis
earch focused on the physiology of

Glen C. Sanderson, retired director of the Center for Wildlife Ecology and winner of the 1992 Aldo Leopold Memorial Award.

reproduction in that species. In the 1960s he headed an important study that implicated skunks and probably raccoons as latent carriers of rabies.

Also a highly respected waterfowl biologist, Dr. Sanderson in recent years has acquired national and international recognition as an authority on lead poisoning in waterfowl. He has been an important factor in the movement to eliminate lead shot for the hunting of waterfowl in the United States. In the March 1988 issue of *Audubon* magazine, Dr. Sanderson was characterized as "a giant in the crusade for steel shot."

For almost 30 years, Dr. Sanderson has played the lead role in cooperative efforts to preserve two remnant flocks of critically endangered native Illinois prairie chickens. The combined efforts of the Illinois chapter of The Nature Conservancy, the Illinois Department of Conservation, and the Natural History Survey have resulted in innovative approaches to land acquisition and management by The Nature Conservancy at the national level.

The publication record of Dr. Sanderson is exemplary, even though he was burdened by administrative duties as head of the Survey's wildlife research unit for 26 years. He has edited five books—namely, *Wild Turkey Management: Current Problems and Programs*; *Midwest Furbearer Management*; *Management of Migratory Shore and Upland Game Birds in North America*; *Ducks, Geese & Swans of North America*; and the forthcoming *The Unique Wood Duck: Its Ecology, Biology, and Management*. He has also contributed 15 chapters to other books, including 13 as senior author. In addition, he was editor of the *Journal of Wildlife Management* in 1971 and 1972. The 1972 volume was 30% longer than the previous longest volume, and his efforts were called "terrific."

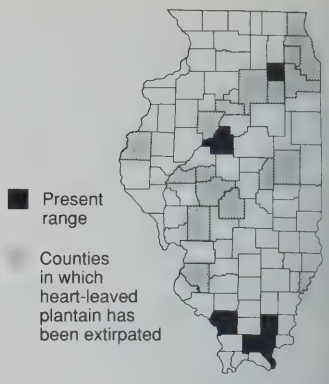
For his outstanding work, Dr. Sanderson previously received several other professional honors, including the Oak Leaf Award of The Nature Conservancy and Conservationist of the Year of the American Motors Company.

Dr. Sanderson has obviously made enormous contributions to the wildlife profession. Furthermore, he did a remarkable job as director of wildlife research at the Survey. He commanded the utmost respect and loyalty from his staff as he efficiently performed his varied tasks with quiet confidence. A top-notch administrator, he was also a colleague, role-model, and friend to his staff. He was never too busy to help but took little credit for his benevolence. Dr. Sanderson has been the "silent soldier" behind many of the accomplishments of the Survey wildlife programs. He is considered a premier leader and spokesman for wildlife and other conservation issues by state agencies and government.

The winning of the Leopold Award by Dr. Sanderson marks the third time that this prestigious honor has gone to staff of the Survey's wildlife unit. Dr. Tom Scott, head of wildlife research from 1950 to 1963, received the award in 1982, and Dr. Frank Bellrose accepted it in 1985. This unprecedented level of recognition is testimony to the quality and significance of the accomplishments of Dr. Sanderson and others associated with the Natural History Survey.
Stephen P. Havera, Center for Wildlife Ecology

Species Spotlight

Heart-leaved Plantain



An endangered species in Illinois, the heart-leaved plantain is now found in only six counties.

The heart-leaved plantain was first described in the United States by plant explorer William Bartram, who wrote in 1773 of a "great species of *Plantago*. . . of incredible magnitude" that he had discovered growing in Georgia. Usually associated with shaded, clean, gravel-bottomed streams, this plant seems to grow best on gravel bars undergoing moderate stream erosion cycles.

In the 1880s *Plantago cordata* was fairly widespread and common in the Great Lakes region. By the early 1900s, however, it had begun to decline throughout most of its range. Previously found in 24 counties in Illinois, this plant currently occurs in less than 10 locations in six counties and is considered endangered within the state.

Although the winter phase, a rosette of small leaves, may resemble the invasive and weedy common plantains (the scourge of well-groomed lawns), by summer the resemblance is gone. Larger than its more common cousins, *Plantago cordata* has deep green and somewhat heart-shaped leaves that may reach a width of 6–8 inches. These broad leaves aid in gathering sunlight, which may be in short supply where this plant is commonly found, in the deep shade of woodlands. The plant's long, thick, cord-like roots can penetrate and cling to rocks and anchor the plant in a stream bed. A slender leafless flower stalk bears small flowers near its tip when the plant blooms in March and April. Wind-pollinated, the heart-leaved plantain produces few seeds.

The seeds are large and have no dormant period, characteristics that aid in the rapid establishment of this species under low light conditions in a shifting stream system. The seeds float if they fall into the water, and they are covered with a sticky coating that makes them adhere to any object they contact. Adapted for water dispersal, the seeds have no efficient means to disperse across land t other stream systems.

Plantago cordata has declined throughout most of its range primarily because of destruction or alteration of it stream habitat. The draining, ditching, damming, and rerouting of streams; the clearing of woodlands for fields, pasture and housing developments; agricultural runoff; and accelerated stream erosion have all contributed to the heart-leaved plantain's demise and made it one of Illinois' vanishing species.

Teacher's Guide to "The Naturalist's Apprentice" (facing page)

"The Naturalist's Apprentice" presents educational activities for middle school students. Teachers are invited to photocopy this feature and "Species Spotlight" for classroom use.

OBJECTIVE: to learn about a few of Illinois' endangered plants and animals and the reasons for their decline

SKILLS/PROCESSES: observation, comparison

VOCABULARY: endangered, threatened, extirpated, extinct, range, deforestation, succession

MATERIALS: copies of "The Naturalist's Apprentice"

COMMENTS: An Illinois endangered species is one that is likely to be extirpated from the state in the near future; a threatened species is likely to become endangered soon. In 1990 the Illinois Endangered Species Protection Board issued a list of 64 endangered and 29 threatened vertebrate animals, 41 endangered and 7 threatened invertebrate animals, and 296 endangered and 60 threatened plants. Are these plants and animals important? David Kenney, former director of the Illinois Department of Conservation, has answered this quite eloquently: "We must always remember that human beings a only parts of a great 'web of life' that includes all living thing no matter how small and unimportant they seem to be. Once that web of life is broken by the extinction of any of its parts, the total structure is weakened, and if a sufficient number of extinctions occur, might itself collapse, leaving mankind the master of all, and ultimately, the master of nothing."

PROCEDURE: **1**. Distribute copies of "The Naturalist's Apprentice" for students to complete in class or as homework

Answers: 1–grass pink orchid, 2–bluebreast darter, 3–dusky salamander, 4–black tern, 5–yellow-headed blackbird

2. Discuss the completed worksheets as a class with questions such as the following: Have you ever encountered any of thes species? Why are some species endangered or threatened in Illinois and not in the rest of the United States? Since extinction is a natural process, why are we so concerned with endangered and threatened species?

EVALUATION: The completed worksheets and discussion serve as the evaluation for this exercise.

Identifying Some Endangered Species of Illinois and the Reasons for Their Decline

e following statements describe 5 of 401 species that are endangered in nois. (They are likely to be extirpated m the state soon.) Read each descrip- n, which identifies the endangered ganism only by its scientific (Latin) me, and find the corresponding wing. Write the species' common mes in the spaces provided.

Calopogon tuberosus was once fairly mmon in prairies, bogs, and fens, stly in northern and western Illinois. day, it is found only in northeastern nois due to habitat loss by urban and ricultural development.
mmon name:

_____

Etheostoma camurum is at the edge of range in Illinois and is found only in Middle Fork of the Vermilion River. ccurs more commonly eastward into Pennsylvania and southward into Tennessee. This species inhabits fast boulder riffles in clear streams. Water quality directly affects this species, and population numbers are lower than in the past.
Common name:

_____

3. *Desmognathus fuscus* is found in Illinois only in Pulaski County in far southern Illinois where it inhabits cold, rocky springs in deep forested ravines. This amphibian is very sensitive to habitat disturbances such as deforestation and lowering of water quality.
Common name:

_____

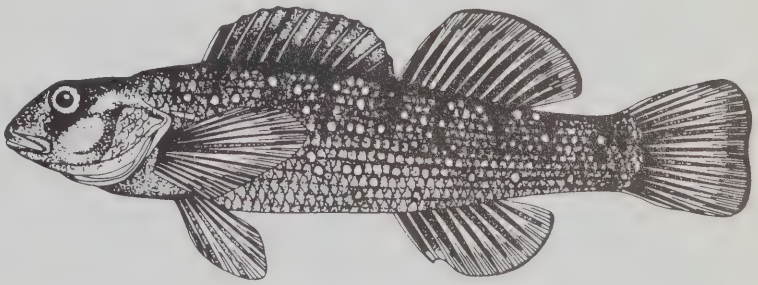
4. Although *Chlidonias niger* occurs throughout Illinois as a migrant and summer resident, its population size is low and is decreasing. Its common habitat is glacial lake edges where it often nests on muskrat lodges. Urban development around these lakes in northern Illinois is significantly decreasing the habitat (vegetation cover and open water) needed by this species.
Common name:

_____

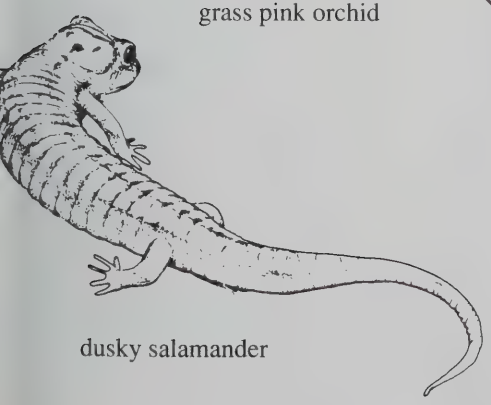
5. *Xanthocephalus xanthocephalus* is at the eastern limit of its range in Illinois. Once commonly found in the large marshes of the Chicago region, this species needs cattails and bulrushes adjacent to open water to successfully nest. Drainage of wetlands, urban and industrial development, and succession in marshes (disappearance of open water and change in plant species) are the main causes for the decline of this species.
Common name:

_____

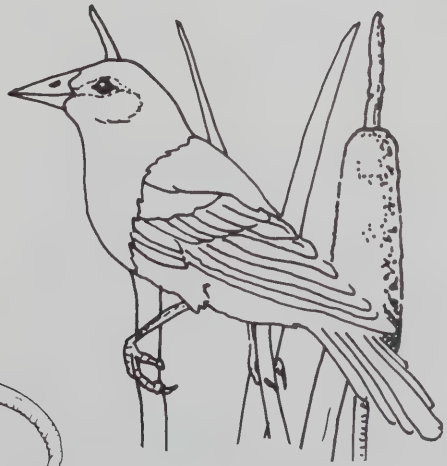
grass pink orchid



bluebreast darter



dusky salamander



yellow-headed blackbird

black tern

"The Naturalist's Apprentice" presents educational activities for middle school students. It is published by the Illinois Natural History Survey, Champaign.

Deer Tick Watch

The deer tick, which spreads the bacteria that cause Lyme disease, has essentially reached statewide occurrence in Illinois. Moreover, some 50 cases of Lyme disease in Illinois residents were reported to the state's Department of Public Health in 1991.

In November and December of 1991, investigators from the Survey, the University of Illinois College of Veterinary Medicine, and Rush Presbyterian St. Luke's Medical Center of Chicago searched for the deer tick on hunter-killed deer at Illinois Department of Conservation check stations. They were assisted by many volunteers from the Department of Conservation, the McDonough and Mercer County public health departments, and other organizations. About 6,500 deer were examined at 81 check stations throughout the state. Infested deer were encountered at 16 stations.

The deer tick has now been detected in 36 counties throughout Illinois.

Nine of these were in counties from which the deer tick had previously been reported, and seven were in counties where the tick had not been found befo The new counties are Stephenson, Henr Coles, Cumberland, Fayette, Lawrence, and Perry. The deer tick has now been detected in 36 Illinois counties since surveying began in the fall of 1987.

Readers of this newsletter are reminded that anyone engaged in outdo work or recreation in Illinois is advised take precautions against tick bites. The best protection is to wear sturdy shoes o boots, long pants with cuffs tucked into socks, and a long-sleeved shirt. Additional protection can be obtained by applying tick-repelling sprays to clothin not to the skin.

Anyone wishing to submit ticks for identification should send them in alcoh to John K. Bouseman at 607 E. Peabody Drive, Champaign, IL 61820.

John K. Bouseman, Center for Economi Entomology

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rairie Chicken Egg Exchanges

the 1860s, there were millions of airie chickens in Illinois. In succeeding ears, the number of prairie chickens ummeted because of widespread nversion of prairie to farmland, heavy nting pressure, and intense interactions ith pheasants and nest predators on linois sanctuaries. The count fell to erhaps 25,000 by 1933, 2,000 by 1963, d only 40 in three isolated populations spring 1992. The dwindling numbers obably led as early as the 1960s to astic reductions in interpopulation ating and gene flow. A high level of breeding may be associated with clining fecundity, and Illinois seems to a classic setting for such genetic oblems.

In a 1943 publication, pioneer urvey wildlife researcher Ralph E. eatter presented evidence for relatively w levels of egg infertility and embryo ortality when the number of prairie ickens (*Tympanuchus cupido pinnatus*) as still in the thousands and populations ere interconnected. From a sample of 39 sts found in Jasper County in 1935–936, Yeatter reported a hatch rate of 3% for 148 eggs in 12 clutches judged have undergone normal incubation. udies in other states, as well as the first ven years of the present Illinois project, und similar hatch rates.

Recently, a database covering more an 1,100 Jasper County nests over 29 ars (1963–1991) was examined for anges over time in reproductive arameters that might be affected by breeding. Although clutch size ap-ared to remain normal, egg fertility, tch rate of all eggs, and hatchability of rtile eggs showed significant downward trends with time. Because of infertility and embryo mortality, the hatch rate of all eggs during 7 of the past 11 years ranged from 70 to 79% and was only 55% in 1990. Such changes in reproductive performance may be symptomatic of inbreeding.

Biologists and volunteers carefully searched sanctuary grasslands for prairie chicken nests.

A host of factors other than inbreeding may also suppress fertility and hatching success of bird eggs. These include pesticides, oil contamination, and aflatoxin from moldy waste grain. Tissue analyses of more than 100 pheasants and a limited sample of salvaged prairie chickens (animals found dead, such as road kills) from Jasper County, however, found negligible levels of chlorinated hydrocarbons (pesticides). Environmental contaminants in general tend to be ruled out by the apparently normal reproduction of bobwhites and pheasants, which often nest near prairie chickens on Illinois sanctuaries and are largely ecological counterparts to prairie chickens. Thus, the available evidence is consistent with a theory of genetic problems—that is, inbreeding—among prairie chickens.

The Survey, the Illinois Department of Conservation, the Illinois Nature Preserves Commission, and the Illinois Endangered Species Protection Board have collaborated to address possible inbreeding depression in Illinois prairie chickens. An effort was undertaken in 1990–1991 to exchange clutches of eggs under incubation in Jasper and Marion counties. The objective was to enhance genetic variation in both gene pools.

INSIDE

◆

Female prairie chicken entering her nest, situated in a clump of grasses and dewberries.

Biologists and volunteers carefully searched 361 acres of sanctuary grasslands in 1990 and 178 acres in 1991. In 1990, unincubated clutches were found in both Jasper and Marion counties on April 25 and 27. Eggs from these nests, which were 40 miles apart, were exchanged on May 18. Both prairie chicken hens returned to their disturbed nests, and despite seemingly great odds (abandonment or predation), both clutches hatched in late May.

A second egg exchange was planned for 1991 but was stymied at the last minute by depredation (presumably by a coyote) of the Marion County hen and her 16 eggs. In a stroke of luck, a clutch of 13 eggs was salvaged by a farmer while plowing in Clay County. These eggs were added to two Jasper clutches estimated to be synchronized in incubation. Subsequently, one Jasper hen hatched both sets of eggs, though the other hatched only her own eggs.

If the foster young survive and breed, the genetic diversity of the two populations may be enhanced. If genetic enhancement and population recovery continue to lag, prairie chicken eggs or grown birds from large thriving populations in other states may be essential. Definitive tests of genetic diversity among salvaged specimens are under way, and more are planned. Documentation of concurrent increases in genetic diversity, egg fertility, hatching success, and prairie chicken numbers would signal a step forward in the genetic management of these birds in Illinois.

Ronald L. Westemeier, Center for Wildlife Ecology

New Publications Available

Several new Survey publications have been issued in recent months. One presents educational activities for junior high and high school students. Organized around the concept of biodiversity, this 48-page publication includes introductory comments and explanatory notes for teachers as well as activity sheets that can be photocopied for classroom use. Written by the Survey's Michael R. Jeffords, *Biodiversity in Illinois: Activities for Young People* includes drawings of plants and animals and a few black-and-white photographs of habitats. Published as Special Publication 13, it can be purchased for $3.

Also available is a set of 40 high-quality color slides designed to supplement the biodiversity publication. Twelve of the slides provide an overview of the biological diversity found in Illinois; the rest relate more closely to specific activities presented in the publication. A four-page booklet describes each photograph. The slide set and booklet can be purchased separately for $6.

Another recent publication is a how-to manual for researchers studying the spread of zebra mussels, which are causing serious problems in North American lakes and rivers. Written by J. Ellen Marsden of the Survey's Lake Michigan Biological Station, *Standard Protocols for Monitoring and Sampling Zebra Mussels* contains sections on zebra mussel biology, methods for sampling mussels at various stages in their life cycle, and reporting of results. Information on equipment and chemicals used in monitoring and examples of various forms and labels are included in appendixes. This 40-page publication, issued as Biological Notes 138, is available for $3.

In addition, two new articles in the Bulletin series were published in May 1992. *Systematics of* Leptosphaeria *Species Found on the Rosaceae*, author by Sabine Huhndorf, was issued as artic 5 of volume 34. This 60-page publicatio includes 21 figures. *Catalog of Types o the Illinois Natural History Survey Mycological Collections (ILLS)*, author by J.L. Crane and Pamela P. Tazik, was issued as article 6 of volume 34. Each o the new Bulletin articles sells for $4.

To obtain any of the Survey's publications, please write to Distributio Center, Illinois Natural History Survey, 607 East Peabody Drive, Champaign, Illinois 61820 (phone 217-333-6880).

John Ballenot, Publications Office

Illinois Wetlands

Wetlands once covered over 8 million acres in Illinois, or 23% of the state. Wi modification of the landscape by humar 90% of the state's wetlands have been destroyed. Documenting the status of th rapidly disappearing resource was difficult without a comprehensive inventory. Through joint efforts of the Natural History Survey, the U.S. Fish a Wildlife Service, and the Illinois Depar ment of Conservation, the Illinois Wetlands Inventory (IWI) has been developed to locate and classify wetlan and deepwater habitats.

The IWI is a computerized databas that stores spatial (map) data on the location, size, and shape of wetland and deepwater areas, as well as descriptive information about each feature. It contains information on ecological and physical characteristics such as area, perimeter, dominant vegetative form (e.g., forest, emergent), substrate type (e.g., rock bottom, unconsolidated bottom), hydrology (e.g., temporary, seasonal, permanent), and human impac (e.g., impounded, excavated, partially drained).

An analysis of the character, extent and distribution of the state's wetlands was conducted using the IWI. Data wer

ald cypress and tupelo swamp in Alexander County. Swamp is one of the rarest types of etland in Illinois.

ggregated and summarized by U.S. eological Survey 7.5-minute quad- ngles, counties, and river drainage asins. A variety of ecological habitat pes—such as bottomland forest, vamp, scrub-shrub, shallow marsh/wet eadow, deep marsh, open water onds), and lacustrine and riverine etlands—were summarized in map and ble formats.

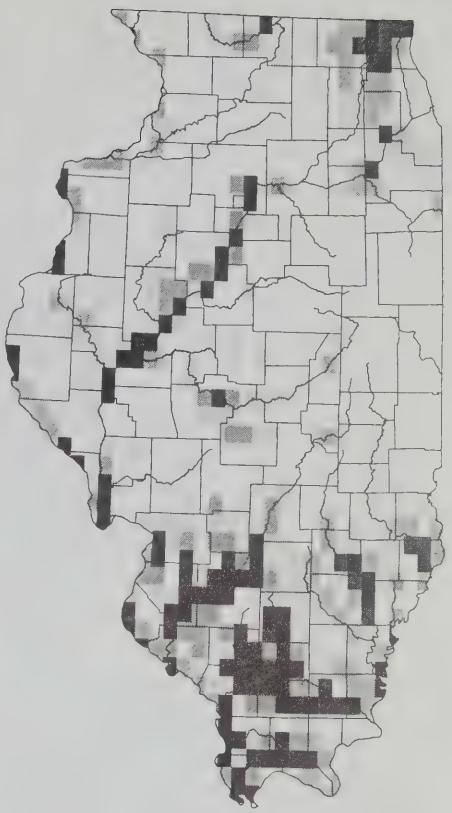
Of the nearly 36 million acres of land Illinois, shallow-water wetlands ccupy 1.25 million acres, or 3.5% of the tal. The most abundant wetland habitat pes are bottomland forest (759,000 res, or 60.5%), shallow marsh/wet eadow (163,000 acres, or 13.0%), and pen water (143,000 acres, or 11.4%); ese three habitat types account for 85% all shallow-water wetlands. Deep arshes and swamps are relatively rare in linois. "Natural" wetlands (that is, those ot modified by dikes, impoundment, or xcavation) account for approximately ree-fourths of the 1.25 million wetland res.

Wetlands are concentrated in ortheastern Illinois and along the inois, Kaskaskia, Big Muddy, Little Wabash, Cache, and Mississippi rivers. The concentration of wetlands along the rivers and in southern Illinois reflects the fact that a large percentage of the wetlands are bottomland forests. Other wetland types exhibit different distribution patterns. For example, wetlands dominated by emergent vegetation (i.e., marshes and wet meadows) are heavily concentrated in northeastern Illinois, an area undergoing heavy development.

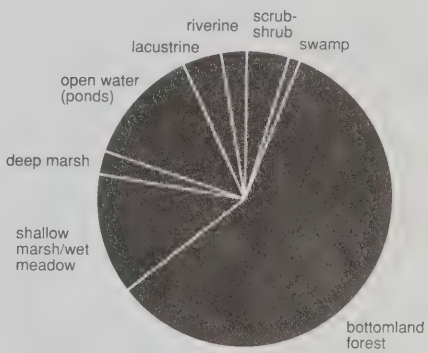
The IWI is unprecedented in its comprehensiveness and accessibility. Among its advantages is an ability to analyze data in a timely manner at levels ranging from local to statewide. This capability recently made Illinois one of the few states able to quickly provide federal agencies with figures for the amount of land that would be affected by proposed revisions to the 1989 *Federal Manual for Identifying and Delineating Jurisdictional Wetlands*. The proposed changes to this manual, which defines wetlands for regulatory purposes, would exclude about 80% of the state's wetlands from federal regulation.

The report generated by the IWI analysis provides an overview of the status of Illinois wetlands and serves as a reference document for resource planners, managers, environmental scientists, policy makers, and others. The Illinois Wetlands Inventory will provide valuable baseline data for future analyses of the state's wetland resource.

Liane Suloway, Center for Biogeographic Information



Distribution of wetlands in Illinois. The darker the area, the more acres of wetlands.



Wetland habitat types in Illinois.

Illinois Desert: Sand Prairie–Scrub Oak Nature Preserve

The gently rolling dune sand of the Sand Prairie–Scrub Oak Nature Preserve in Mason County contrasts sharply with the black soil of most of central Illinois. Deposited in the Illinois River valley a few thousand years ago by the meltwaters of the Wisconsinan glacier, this sand creates a special home for a unique collection of plant and animal species.

The flora here is a combination of plants common to the tallgrass prairie of Illinois and western plants usually associated with drier, open habitats. The western species probably arrived in Illinois thousands of years ago, when the climate was warmer and drier. As Illinois became cooler and moister, these species died out in most areas but persisted here because of the special environnment provided by the desertlike sand.

The vegetation of the dry sand prairie is strikingly different from that found on the black-soil prairie. Although the sandy areas receive the same amounts of heat, light, rainfall, and wind as the rest of the state, they experience larger variations in temperature from day to night and from surface to subsoil; the water-holding capacity of the sandy soil is also very low. In open areas, the surface sand is constantly shifting, sometimes forming dunes or blowouts (areas where the sand and vegetation are blown away by the wind).

To survive in the sand, plants have evolved several strategies. Visitors to the preserve should note that the leaves of many plants are narrow or small, thereby reducing the amount of surface exposed to the sun. Leaves may have a protective covering of silvery hairs or scales, giving them a grayish-green color. Perennials have developed deep roots in response to the limited supply of surface water and frequently grow in tufts or bunches to reduce exposure to the wind. Plants such as the prickly pear cactus have thick, succulent leaves and form mats that grow close to the sand and that tend to spread over a larger area each year.

Small, scrubby oaks are interspersed over much of the Sand Prairie–Scrub Oak Nature Preser

Spring usually comes early to Sand Prairie–Scrub Oak. At first, the plants are small, growing in clumps that allow the sand to show through. As a result, the area has a tufted appearance similar to that of a true desert. The first blossoms to appear are those of the sand phlox, followed by the pansylike bird's-foot violet. Each succeeding day adds not only to the floral display but also to the greenery as bunch grass begins to cover the sand. Spring is the only season that is truly green in the sand prairie. By late spring, the luminous yellow-orange blossoms of puccoon mingle with the various shades of violet spiderwort, whose long, linear leaves help to conserve moisture.

By summer, yellow is the color of the sand prairie. Dwarf dandelion, coreopsis, black-eyed Susan, the bright orange of butterflyweed, and the waxy-yellow blossom of prickly pear cactus dominate the landscape. The large, silken cactus flowers provide much-needed nectar and pollen for insects during June, and butterflyweed provides an abundant summer nectar source for many species of butterflies, including tiger swallowtails. Specimens of each showy pla are scattered through the ever-present June, grama, and needle grass.

By late summer, the dryness of the sand is evident. Grasses are begining t turn brown and the landscape is broke only by tall, slender, pink spikes of blazing-star. Some are so top heavy the fall over, making perfect arcs in the coarse sand. The drone of katydids and the summer wind are the only sounds;

Practical Information

Sand Prairie–Scrub Oak Nature Preserve is about 40 miles northwest of Springfield and is near the town of Bath. From Bath, located on state route 78, take a blacktop road east 3.(miles, then turn right and go south fo 1.3 miles. The preserve is west of the road. For additional information, contact Site Superintendent, Sand Ridge State Forest, Forest City, IL 61532 (phone: 309-597-2260). The 1,460-acre site is owned by the Illino Department of Conservation.

ull snake, which leaves wavy tracks in the sand.

Prickly pear cactus.

ppressive heat rises in rippling waves ver the rapidly browning landscape. The ommon six-lined racerunner lizard and ccasional bull snake leave their sinuous arks in the undulating sands.

Fall is dominated by brown bunch asses and the occasional scrub oak owing on an ancient dune. When the egetation withers with the coming of ost, the sandy soil becomes visible once ore.

The migration of tree species onto e sand prairie eventually results in sand vannas. These two-layer communities ve a 10–80% canopy coverage of trees d a nearly continuous ground layer of airie plant species. Sand savannas, like her savanna communities, were aintained by fire in presettlement times. ne rhythmic dunes and ridges limited e severity of fires and allowed a vanna to develop instead of a sand airie.

The seedlings of only a few species trees can withstand the extreme nditions of the shifting sand—the hot rface in summer and the lack of otection against winter winds. Oaks minate the early stages of a sand vanna, and to a large extent they, and a w hickories, determine the ecological ture of the forest that may subsequently velop on the sandy soil. Because of the

Tiger swallowtail on ironweed.

Blowout area (see text) with scrubby oaks.

arid nature of the soil, the trees remain small and "scrubby." The herbaceous flora consists of familiar perennial herbs, such as spiderwort and puccoon.

Although there are no formal trails through the 1,460-acre preserve, the area is open and makes for easy walking. Visitors who hike the preserve are rewarded with vistas with no evidence of human disturbance. Such views allow one to experience a part of Illinois as the early settlers did, in pristine, quiet solitude and contemplation.

Text and photos by Michael Jeffords, Center for Economic Entomology, and Susan Post, Center for Biodiversity

Species Spotlight

Pileated Woodpecker

The old adage that a lumberman is known by his chips certainly applies to the pileated woodpecker. When it attacks with powerful staccato blows, a dead tree or limb can be reduced to a blanket of splinters and chips in half an hour or less!

The pileated, *Dryocopus pileatus*, is the largest woodpecker in Illinois. This very active and noisy bird, with its imposing size and striking colors, is very conspicuous in its forest environment. About the size of the common crow, this black bird has a bright, poppy-red crest and white bars that flash on its wings as it flies. The pileated has several calls, including the strident *kik-kik-kik*, but perhaps the most distinctive is the drum. The mellow yet powerful boom of a hollow tree struck by the hammerlike beak resonates throughout the forest—a solemn, ancient sound.

Arboreal in its habits, the pileated is a permanent resident in the remaining heavily forested areas of the state, preferring bottomland forests over the uplands. When the wild expanses of forest dwindled to tame woodlots by the turn of the century, the pileated—along with the wild turkey, barred owl, and raven—began to disappear. By the 1920s, though, pileated populations had begun to rebound as the birds slowly became accustomed to civilization and the second-growth timber became large enough to supply food and nesting sites. Today, these woodpeckers can even be found near some Illinois cities, including Champaign-Urbana.

The pileated woodpecker, *Dryocopus pileatus*.

Although the pileated will eat fruit, most of its diet consists of grubs, wood-boring beetles, and, possibly, ants found in decayed wood or stumps. A bird will stay with a tree until all food has been consumed. The pileated's control of forest tree insect pests is of considerable value to the forest.

Pileateds, like all woodpeckers, are adapted to an arboreal lifestyle. Their le are short and stout, and their toes have strong, sharp claws. Two of their four toes point forward and two, backward. Their tails are composed of stiff feather terminating in sharp spines that can be pressed against the bark to prop up the bird while it is at work. The stout beak, with its chisel-shaped point, is effective for cutting wood. All these adaptations enable the woodpecker to easily cling t trunks and branches and to strike hard, effective blows.

Pileateds usually nest in a dead tree or tall stump. The hole is 7 or 8 inches long and 4 to 5 inches wide and may be feet deep. A pair usually works for a month on the nest. Although the wood-peckers may return to the same nesting tree year after year, a new nest hole is always constructed. After abandonment old nesting cavities are used by flying squirrels, owls, and tree-nesting ducks.

These denizens of forests and swampy areas connote wildness. A glimpse of a pileated is a tremendous thrill, whether it be the observer's first sighting or the thousandth. For the novi birdwatcher, a sighting evokes the inevitable cry "there goes Woody Woodpecker!"

Teacher's Guide to "The Naturalist's Apprentice" (facing page)

OBJECTIVE: to learn about the forests of Illinois through math problems

SKILLS/PROCESSES: problem solving, graph and chart interpretation

GLOSSARY: deforestation, second- or third-growth timber, woody, nonwoody

MATERIALS: copies of "The Naturalist's Apprentice"

COMMENTS: Although Illinois originally had about 14 million acres of forest, forests today cover only about 4 million of the state's 36 million acres. Also, much of today's forest represents second- or third-growth timber or pine plantations; only about 13,500 acres of relatively undisturbed forest re-mains. Two obvious benefits of forests are wood products and recreational opportunities for hiking and camping. More subtle benefits include the role forests play in controlling erosion, preserving water quality, and maintaining biodiversity. Sixty-one percent of the plants native to Illinois and 75% of its wildlife habitat are found in forests.

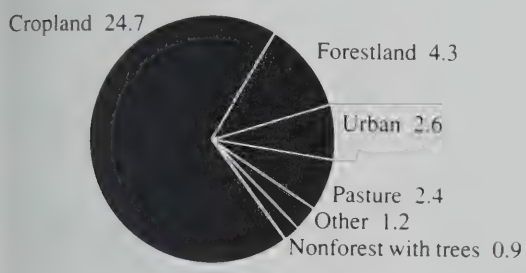
PROCEDURE: Distribute copies of "The Naturalist's Appren tice" and have students work the problems in class or at home. *Answers: **1**. 12%, 6.7%, 7.2% **2**. 82.3% **3**. 69%, 1,414, 2,818, 12.6%, 46.6% **4**. 1880, decreasing, increasing, about 1.5% **5**. 8 million, 0.2%, 7,975,000.*

EVALUATION: Have students write a brief explanation of th following quotation by Robert O. Petty, including an interpreta tion of the last sentence: "Like the first farmsteads, towns of th frontier were built in stumpland meadows. The trees were gone The civic landscapes sweltered in the sun. Never so quick an afterthought: fast-growing black locust trees were imported an planted everywhere, from college campuses to courthouse squares, to provide a promise of shade. What irony—the sons the world's most incredible axemen planting seedlings in the shadow of stumps five feet across."

Arithmetic of the Forest Resources of Illinois

mplete the following problems with information from the t or figures.

The pie chart below shows the amount of land in Illinois that devoted to various uses. Values are given in millions of acres. e total area of Illinois is about 36 million acres.



hat percentage of Illinois is forestland? _____

sture? _____ Urban areas? _____

Illinois has about 1.94 billion trees, including 344 million ns.

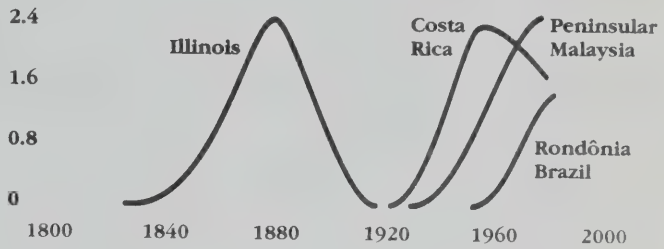
hat percentage of the trees in Illinois are *not* elms? _____

Use the information below to complete the short paragraph t follows.

> About 500 species of trees, shrubs, and woody vines are found in Illinois; 345 are found in forests.
> At least 61% of the 2,318 species of nonwoody plants that occur in Illinois are found in forests.
> In Illinois, 356 species of plants are considered threatened or endangered, and 166 of these are found in forests.

the trees, shrubs, and vines found in Illinois, ____% of ecies are found in forests. In addition, _____ species nonwoody plants occur in forests. A total of _____ plant ecies are found within the state. Many of Illinois' plants are y rare, and _____% of the total number of species are nsidered threatened or endangered. Among these threatened endangered species, ____% live in forests.

Environmentalists are now concerned about the cutting of es in tropical rain forests. The following graph compares rates of deforestation in tropical forest areas with deforestation rates in Illinois in years past. The rate of deforestation (left axis) is expressed as the percentage of forest lost each year.

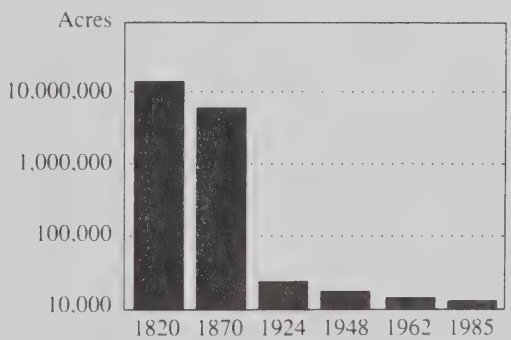


The rate of deforestation in Illinois reached its peak in _____.

The rate of deforestation in Costa Rica is [increasing, decreasing, reaching its peak]. (circle one)

In Brazil, the rate of deforestation is [increasing, decreasing] and is currently at ____% per year.

5. The bar graph below shows the number of acres of primary (undisturbed) forest in Illinois at various times in the past.



Approximately how many acres were covered by primary forest in 1870? _____

About what percentage of the primary forest of 1820 remained as primary forest in 1948? _____

How many acres of primary forest were lost between 1870 and 1948? _____

Ash Yellows Disease

Ash species constitute one of the most important tree groups in urban areas. Although ashes currently rank below maples in importance as street trees, this may soon change because ashes, unlike maples, are resistant to attack by gypsy moth caterpillars, which eat tree leaves. Other qualities that enhance the desirability of ashes include an ability to grow in clay soils and a tolerance to air pollution.

A factor that could decrease the desirability of ash species is a recently discovered disease called ash yellows, caused by a bacteria-like organism. Discovered in the Midwest in 1986, this disease has caused a serious decline in the numbers of ashes in the Northeast. Symptoms of ash yellows include a loss of tree vigor, branch dieback, and in advanced stages the development of witches'-brooms (abnormal tufted growths of small branches) on the trunk near the root collar. Once a tree is infected, there is a general decline in vigor over several years, followed eventually with the death of the tree. There is no known cure for an infected tree, although recent studies at Cornell University have shown that watering during dry weather and fertilizing in the spring may help an infected tree to survive for a longer period of time.

To investigate the distribution of the disease in Illinois, a recent survey was conducted in cooperation with the Illinois Department of Conservation and the U.S. Forest Service. Nineteen sites throughout Illinois with substantial ash stands were visited, and samples were taken and analyzed at Cornell University. The eight stands found to be infected were located in seven counties, ranging from Ogle County in the north to Pope County in the south.

How the disease is transmitted remains a mystery, but insects are suspected as potential vectors. Further studies at the Natural History Survey will be conducted to improve our understanding of this disease.

James E. Appleby, Center for Economic Entomology

Ash yellows disease was found in seven Illinois counties.

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REPORTS

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nderstanding Termites

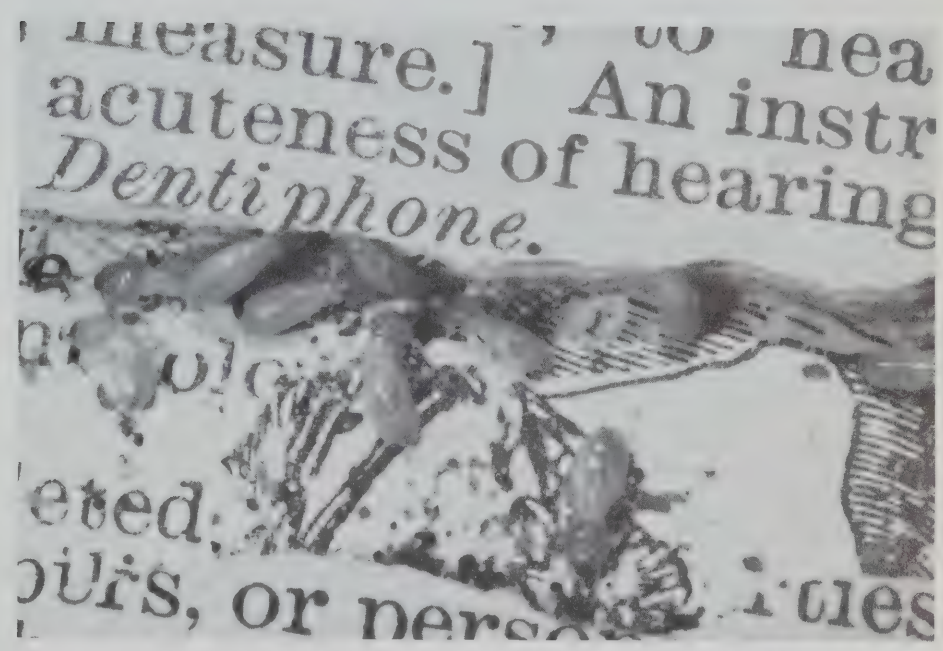
lthough many people think of termites nly in terms of the damage they can do buildings, studies have shown that ese creatures have an interesting social rganization and that they play an nportant role in decomposing dead trees nd other woody material. Ongoing udies are also leading to better methods r controlling these insects when ecessary.

Illinois is home to several species of rmites. The most important is the astern subterranean termite, *Reticuli-rmes flavipes*, which is the species that tacks buildings.

The underground colonies of this rmite species consist of workers and ldiers, which are reproductively sterile, well as reproductively capable males nd females. The workers forage through e soil for wood to bring back to the lony. They are about 1/8-inch long and hite.

The soldiers guard the colony and otect the workers during foraging. The ldiers are slightly larger than the orkers and have a large, brownish head ith huge jaws. The head and jaws make about one-third of the total body ngth. Ants are usually the biggest threat a termite colony, and the soldiers are ry capable of defending the colony or workers from ant attacks. Soldiers do t gather food, and they are fed by the orkers.

Termites play an important role in e natural ecology by helping to return llulose to the nutrient cycling process. ellulose, found in structures such as tree nks and plant stems, cannot be chemi-lly broken down by most digestive ocesses. Thus, most animals cannot



Termite workers and feeding damage in a dictionary. Termites attack books only if the books are not used for long periods of time.

digest wood or other materials containing cellulose. Also, although cellulose *can* be digested by some microorganisms, these tiny creatures can accomplish this feat only on small plant pieces such as leaves and stems that fall to the soil where the microorganisms live.

Termites are especially important for their role in breaking down the cellulose in large pieces of wood, such as fallen trees. Termites, as well as woodroaches and some other creatures, carry in their guts small organisms called protozoans that can digest the cellulose that the termites eat. Termite tunneling in wood, such as dead trees, also allows entry of water, soil, and microorganisms that help to break down the wood; this enables the return of nutrients to the environment long before it would occur by the action of soil microorganisms alone.

In general, termites are attracted by wood in contact with moist soil. Drier soil areas tend to have fewer termites than moister areas. Softwoods, such as pine, fir, and spruce, contain various resinous substances that termites avoid. Redwood, cedar, and cypress contain enough of these substances to repel termites for many years. Hardwoods, such as oak,

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To enter buildings, termites build tunnels over masonry, unsuitable wood, and other barriers.

birch, and ash, do not have as many of these substances and are the preferred food of termites.

Termite workers enter buildings easily where wood is in contact with the soil. They will also build pencil-sized tubes of mud across foundations or go up through cracks in the foundation to get to wood. They eat wood in layers, leaving what corresponds to many of the dark growth rings in the original tree. These growth rings are produced during slower growth periods, resulting in a higher concentration of the chemicals that the termites avoid.

Termite workers need high humidity and will carry mud up into the wood where they are feeding to maintain a 97.5% relative humidity. For this reason, dried mud can usually be seen in areas where feeding has occurred. For the same reason, termites will not make a hole to the outside that allows drier, outside air into their tunnels. They do not leave sawdust; all of the wood that is gathered is carried back down to the nest.

Termites are controlled by treating any soil that contacts the building with an insecticide. Although the chemical chlordane was commonly used in the past and will repel termites for at least 35 years, it was taken off the market because it causes cancerous tumors in laboratory animals and even properly treated buildings will have small amounts of chlordane in the air for years after treatment. Chlordane-caused cancers have not, however, been demonstrated in humans.

A variety of insecticides are on the market today for the control of termites. They are effective for five to 15 years. All of them are highly insoluble in water, a trait that makes them unlikely to leach into groundwater and that causes them to remain along the building where they will provide protection against termite invasions.

Proper termite treatments usually involve masonry drills, metered pumping equipment, other specialized equipment, and special application knowledge. Pest control operators should be hired for any such treatments. It's wise to obtain at least three bids because fees vary widely. A guarantee or annually renewable contract should be purchased for at least the first three to five years after treatment.

Less intense chemical alternatives to termite control are being researched. Recent control efforts using nematodes (worms) that attack and kill termites w effective in the laboratory but not in fi situations. Sand of the correct particle size alongside building foundations ha been effective in drier climates such as California and Hawaii and is being researched in the Midwest.

The use of wooden bait blocks impregnated with an insect growth regulator is showing promise in researc The growth regulator causes the termit colony to produce an abundance of soldiers that do not gather food, causin the colony to starve. This experimental method is still several years away from practical application.

Philip L. Nixon, Center for Economic Entomology

Effect of Drought on Stream Fi

Droughts are not unusual in the Midwe Streams in east-central Illinois are particularly affected by droughts becau this region is dominated by surface drainage and shallow tile drainage fror row-crop agriculture. An extreme drou in 1988 dried low-order (small) stream in the Salt Fork basin in east-central Illinois so that only 20% of the total stream length in the basin contained flowing water during the spring and summer. This drought provided a natu experiment in which the rate of recove of fish populations could be measured when normal flows resumed.

Eighty-eight samples of fish taken under standardized procedures and corrected for gear collection efficiency were obtained during 1987 (29 sample 1988 (20), 1989 (31), and 1990 (8) throughout the Salt Fork basin. These samples covered reaches 45–77 meters long (about 150–250 feet) and were tal during July through September, a perio in which fish biomass is maximized an relatively well distributed spatially. M samples (79) were taken using an elect seine, but samples from all capture techniques were corrected for their respective efficiencies. Therefore, resu

ere obtained as estimated biomass ther than catch—or alternatively, as timated species richness (number of ecies) rather than species richness of tch—and are thus independent of the ar utilized and of site properties that ay influence catchability.

In nondrought years 90 tons of fish ccupied the 729 kilometers (about 450 iles) of streams in the basin (see table elow). Although drought reduced total ream length by 80% in 1988, fish iomass was reduced by merely 17% ecause only lower order streams were esiccated; these streams normally have uch less total fish biomass and a lower iomass density than permanent streams. hus, about 15 tons of fish was lost in the asin during the drought of 1988. This rovides a minimum estimate of the ermanent loss that would be sustained if ontinuous water extraction during the ummer were to become widespread.

The biomass reduction in 1988 had o measurable effect during the following vo years, and species richness in the wer order streams after the drought was distinguishable from that in 1987. In a eparate, localized study of the recovery f three desiccated streams, biomass and ecies numbers returned to within pical ranges by the summer of 1989, espite the low water levels prevalent uring that year.

In 1988, 80% of the total stream length in the Salt Fork basin had no flowing water.

Analyses also indicated no significant change in permanently flowing streams in biomass or species richness before, during, and after the drought. Therefore, there was no indication of increased biomass or species richness in permanent streams due to concentration during the drought.

In this case history of a natural drought in the Salt Fork basin, the biomass in the upper stream reaches returned to normal levels in 1989 and 1990, despite the fact that a "semi-drought" occurred in 1989. This large-scale analysis supports previous observations by Survey scientists of the fast colonization of individual decimated streams and stream reaches in east-central Illinois and indicates that the fish species of the Salt Fork basin are well-adapted to temporary disturbances in surface flow, providing the species have access to permanent refuges downstream.

In conclusion, we argue that fish stocking and other restoration procedures are not necessary following similar droughts, due to the short time required for natural colonization of fish and recovery of fish communities when normal flows return. This may not be the case in higher order streams if the sources of colonizing species are adversely affected, or in projects involving water extraction from hydrologically stable streams in which adaptations for rapid colonization may be poorly developed.

P.B. Bayley and L.L. Osborne, Center for Aquatic Ecology

iomass estimates of fish (all taxa except darters) in the Salt Fork basin under ormal conditions.

rainage etwork	Stream length, km*	Fish biomass, tons	% of total biomass	Biomass per unit area of water, kg/ha*
Vhole basin	729	90.0	100	270
ll streams that ere permanent 1988	146	74.6	83	319
ll streams that ere desiccated 1988	581	15.4	17	173

km = kilometers; kg/ha = kilograms per hectare. 1 km = 0.62 miles; 1 kg = 2.2 pounds; 1 ha = 47 acres.

Beall Woods

The eastern border of Illinois was formerly the site of what some considered one of the wonders of the world: the great trees that made up the last stronghold of the eastern deciduous forest. The bottomlands of the Lower Wabash River contained deep, fertile, well-drained soils with constant moisture, conditions ideal for the very best tree growth. These were primeval woods with trees more than 130 feet tall and trunks 6 feet or more in diameter. Old sycamores had great white branches as large as ordinary tree trunks, stark pale ghosts of perhaps even larger trees before them. Tulip trees, originally very abundant, vied with the sycamores as the giants of the forest. The woods were also diverse, with a great variety of species growing together and no single species dominating. But it was the immense size of the trees, not their identities, that made perhaps the strongest impression on those who viewed those virgin woods.

Robert Ridgway, a Smithsonian naturalist and author of a Natural History Survey publication on the ornithology of Illinois, spent much of his time here during the 1870s studying the birds and noting the species richness and the immense size of the trees. Through photographs and measurements, he documented the extraordinary nature of the bottomlands. According to Ridgway, the lower Wabash Valley consisted of a mixed woods. Within a single area he found trees characteristic of various regions of the United States: beech, sugar maple, and the various oaks of the North; bald cypress and tupelo gum of the South; and catalpa and pecan of the Southwest. These woods contained more than 90 species of trees, many reaching their longitudinal and latitudinal limits. The original forest was so dense that trees had to grow upward to obtain enough sunlight, and many species grew to enormous heights. Undergrowth formed a dense and impenetrable thicket overrun with wild grape and poison ivy. The vines hanging from branches looked like monstrous suspension cables. Flowing between the dense walls of this forest was the Wabash. Ridgway wrote, "If viewed from a high bluff the forest presented the appearance of a compact, level sea of green, almost endless; tree tops swaying in the passing breeze and the general level broken by occasional giant trees which rear their massive heads to overlook the surrounding miles of forest."

Fall aspect in nature preserve at Beall Woods.

Although no virgin stands remain in Illinois, we can still experience the woods that Ridgway knew. Beall Woods, an Illinois State Park and U.S. National Natural Landmark, consists of more tha 600 acres on both sides of Sugar Creek southern Wabash County. Two hundrec seventy acres within the park and bordering the Wabash River has been dedicated as an Illinois Nature Preserve The woods had been owned by the Beal family for more than 100 years. Past us of the woods have included grazing by hogs and cattle, hunting, mushroom collecting, and harvesting of walnut, sweet gum, burr oak and tulip trees. Th

lyphemus moth caterpillars on oak.

Mayapple thicket on upland above Coffee Creek.

rest ranges from well-drained, rolling lands, to low areas subject to flooding d standing water. The diversity of sites s produced a large concentration of tree ecies for one area. Seventy-four tree ecies have been identified here, and proximately 300 trees have trunks with ameters greater than 30 inches at breast ight. State tree champions include umard red oak, green ash, sugar berry, d sweet gum.

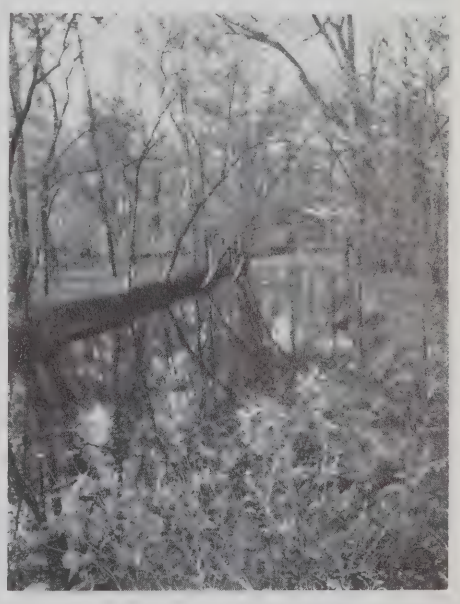
A visit to Beall (pronounced *bell*) oods should begin in the Red Barn ature Center. As you enter the door your eyes are immediately drawn to an immense yellow circle painted on the floor—a representation of one of the last tree giants to meet the ax. The circle is 17 feet across. By wondering around the center, you can get a glimpse of the past by looking at Ridgway's black and white photographs and field notes. The park's numerous hiking trails begin at the rear of the visitor center.

In the spring the brown understory of fallen leaves is broken by spring ephemerals, with bloodroot and mayapple forming large patches. More than 100 species of birds have been identified in the park, including yellow-throated and cerulean warblers, scarlet tanagers, and pileated woodpeckers, all typical of mature woods. Autumn provides perhaps the most spectacular fall color show in the state.

To appreciate this region of Illinois today requires a sense of the past. Here was the last citadel of the eastern deciduous forest before the onset of the endless prairie, a home to giant trees and lush vegetation. Although the area has been strip-mined, cultivated, and grazed, these few remnants help to recapture the forest that our ancestors saw.

Text and photos by Susan Post and Michael Jeffords, Center for Economic Entomology

Acorn weevil adult. Larvae feed in acorns.



Floodplain forest along Coffee Creek.

Practical Information

Beall Woods is in southeastern Illinois near Keensburg, which is on Route 1 about 10 miles north of I-64. From Keensburg, take a blacktop road 1.5 miles east to Beall Woods. Trails begin at the Red Barn Nature Center.

For additional information, call 618-298-2442, or contact the Illinois Department of Conservation, Natural Heritage Biologist, Dixon Springs State Park, R.R. 2, Golconda, IL 62938 (618-949-3305). **Anyone traveling to the area should first contact the Illinois Department of Conservation to assess the status of the area and its trails.**

Species Spotlight

The Common Striped Scorpion

People sometimes associate scorpions with the horoscope sign Scorpio or with a constellation of stars, but more often these creatures are thought of as deadly killers, the scourge of deserts. Of the 1,500 species of scorpions worldwide, however, only 25 are poisonous enough to kill a person. The others are no more than efficient predators whose sting is less painful than a honeybee's.

Scorpions are arachnids, relatives of spiders, ticks, and mites. Their bodies are divided into two regions: cephalothorax and abdomen. Attached to the cephalothorax are six pairs of appendages—the chelicerae, pedipalps, and four pairs of legs. The pedipalps are large claws used for defense, prey capture, and sensory perception. The chelicerae are used for mashing and shredding food.

The abdomen is divided into segments and ends with a sharp, curved spine. The base of the spine is enlarged and contains a pair of poison glands. On the underside of the abdomen are a pair of comblike sensory structures called pectines. Most scorpions have eight simple eyes that enable them only to distinguish between light and dark.

The common striped scorpion is found in a few locations in southwestern Illinois.

The common striped scorpion, *Centruroides vittatus*, is found in a few locations in southwestern Illinois. The most widely distributed American scorpion, this species is nocturnal: it hides under rocks, old logs, or loose tree bark during the day and emerges at night to feed and drink. These scorpions feed mostly on spiders and insects. If the prey is large or active, it will be stung repeatedly until it is subdued. The chelicerae then macerate the prey so the juices can be swallowed. As long as water is available, scorpions can survive without food for several months.

Adults of this species average 2 1/2 inches long and have two broad, brown longitudinal stripes toward the back of the abdomen. Their sting causes a temporary, localized pain in humans and sometimes slight swelling.

Females give birth to 20–50 live, but not fully developed, young after a gestation of 8 months. The young crawl about on the female's back until after their first molt at 1–2 weeks. If one should happen to misstep while crawling over the female's cheliceral area, it provides a tasty snack for "mom."

Scorpions lead individual lives and usually avoid each other. When individuals do meet, they usually either engage in courtship or fight to the death. The greatest threat to their continued existence is food shortage, drought, and human activities.

From ancient times, humans have usually feared and hated the scorpion. Unfortunately, little has happened over the ages to alter those feelings.

Teacher's Guide to "The Naturalist's Apprentice" (facing page)

OBJECTIVE to acquaint students with the characteristics of various arthropods

SKILLS/PROCESSES deduction, visual discrimination

GLOSSARY class, cuticle, exoskeleton, segment, cephalothorax, thorax, phylum, abdomen

MATERIALS copies of "The Naturalist's Apprentice"

COMMENTS Arthropods are the most successful animals: they exist in incredible numbers, constitute an immense number of species, and occupy nearly all habitats. Arthropods have an exterior covering, called a cuticle or exoskeleton, that is arranged into segments, which are usually grouped into two or three regions. Some segments have one or more pairs of jointed appendages.

The major classes of the phylum Arthropoda are the Chilopoda (centipedes), Diplopoda (millipedes), Crustacea (lobsters, crayfish, crabs, shrimps, waterfleas, and barnacles), Arachnida (scorpions, spiders, ticks, and mites), and Insecta. Distinguishing among these classes is the subject of this edition of "The Naturalist's Apprentice."

Centipedes are wormlike creatures with a flattened body and one pair of legs per body segment. Millipedes are similar but have a more rounded body with two pairs of legs on most segments. Although the crustacea are highly variable, all have two pairs of antennae, body segments grouped into two regions (the cephalothorax [head and thorax combined] and abdomen) and at least five pairs of leglike structures. The arachnids lack antennae and have two body regions and six pairs of appendages; the first pair are fang- or jawlike and the second pair are somewhat feeler- or clawlike. The remaining four pairs are usually leglike. Insects have a single pair of antennae, three body regions (head, thorax, and abodmen), three pairs of legs, and often one or two pairs of wings.

PROCEDURE **1.** Give a copy of "The Naturalist's Apprentice" to each student.

2. Have students match the descriptions with the drawings. Note: A description may match more than one drawing.

EVALUATION Send a student or group of students to the chalkboard. Recite the characteristics of one of the above classes of arthropods and have the student or students draw an animal that possesses those characterisitics. Have the class serve as judge as to whether the completed animal is identifiable as a member of the class of arthropods you described. Have the student make any changes the class deems necessary.

a Class by Themselves: Distinguishing among the Five Major Classes of Arthropods

ad the following lists of characteristics
t define the five major classes of the
ylum Arthropoda. Match the letter
ociated with each drawing to the
per list or lists of characters.

ass Chilopoda
rmlike body
dy flattened
e pair of legs per body segment

_____

Class Arachnida
two body regions
no antennae
four pairs of legs

_____

Class Diplopoda
wormlike body
body fairly round
two pairs of legs per body segment

_____

Class Insecta
three body regions
one pair of antennae
three pairs of legs
wings sometimes present

_____

Class Crustacea
two body regions
two pairs of antennae
at least five pairs of leglike structures

_____

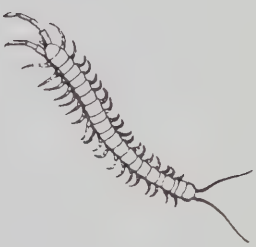
A

B

C

D

E



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Bismuth Shot Shows Promise

For more than a century, waterfowl have become sick and sometimes died from ingesting spent lead shot inadvertently deposited by hunters in the birds' feeding areas. In response to this lead-poisoning problem, federal regulations have since 1991 mandated the use of nontoxic shot for waterfowl hunting in the United States. Although steel shot has been approved as nontoxic by the U.S. Fish & Wildlife Service, there is continuing interest in developing other types of nontoxic shot.

Before the U.S. Fish & Wildlife Service will approve studies to evaluate a shot, the applicant must show a basis for its nontoxicity. In 1991, scientists in the Center for Wildlife Ecology, with assistance from Dr. George L. Foley of the University of Illinois College of Veterinary Medicine, conducted a preliminary study to determine whether bismuth shot is nontoxic when ingested by waterfowl. Bismuth occurs naturally in the earth's crust and is obtained as a byproduct in the processing of lead, copper, and tin ores.

The study divided 120 mallards into 12 groups of 10 ducks each. Groups were fed various amounts of iron, lead, or bismuth shot; both lead and bismuth shot; or no shot.

The bismuth shot caused no anemia and had no apparent effect on body weight, and bismuth levels were low in blood, muscle, bone, and liver of ducks administered the bismuth pellets. These findings, as well as previous studies of bismuth in mammals, suggest that most of the bismuth eroded in the mallards' gizzards was excreted in the feces without being absorbed in the gastrointestinal tract. In addition, the bismuth shot disappeared quickly from the ducks' gizzards: an average of only 22% of the weight of the bismuth shot remained in recognizable pellets in the gizzard after 30 days.

An interesting sidelight is that several of the disk-shaped bismuth shot remaining in the gizzards were longer than the diameter of the shot as originall administered. The only plausible explan tion is that the gizzards exerted enough pressure on the pellets to flatten them. I a subsequent test, a pressure of 50 poun per square inch in a hydraulic press was required to flatten bismuth pellets to the degree that the disks were flattened in th gizzards.

At the end of the study, necropsies controls (those receiving no shot), ducks dosed with eight steel shot, and those dosed with eight bismuth shot showed n significant differences among the ducks This preliminary study thus suggests tha the ingestion of bismuth shot will have serious adverse effects on waterfowl.

Whether bismuth shot will ultimate be approved for waterfowl hunting in th United States is unknown. Also, this study did not consider possible toxic effects of bismuth shot on other species aquatic (especially anaerobic) environments.

Glen C. Sanderson, Center for Wildlife Ecology

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ne Future of Cottontails

many Illinoisans, the cottontail *lviligas floridanus*) seems to be erywhere. Those who hunt cottontails, wever, may wonder whether the future this species should be taken for nted—at least in rural settings.

There has been a dramatic decrease rabbit abundance in Illinois in recent cades. Although hunters in the late 50s annually bagged 5–6 million bits, by the late 1970s fewer than 1 llion were taken per year, and the mber taken has risen only slightly since n. Nonetheless, the sport of rabbit nting remains very popular and is portant to local economies in the state. study by the Illinois Department of nservation determined that about 3,000 rabbit hunters spent $25.4 llion hunting in 1989, with each hunter ging an average of 7.7 days afield and ing an average of 10.3 rabbits during season.

Why have cottontail numbers clined? Through the 1950s farming in nois was relatively compatible with the eds of rabbits. Elements of farm dscapes that traditionally contributed an abundance of cottontails included sture, rotations of hay and oats, fallow pland, crop stubble left over winter, shy field borders, and savannas. All of se components of habitat abruptly minished during the 1960s and 1970s, en row crop production surged.

With farm landscapes continuing to ange, what does the future hold for the ttontail in Illinois? Are there modern ming practices that are relatively orable for rabbits? To address these estions, Survey biologists have tiated research studies along several fronts. For example, county-level changes in abundance are being evaluated for the mid-1950s through the 1980s. There appear to be distinct patterns in how land use and habitat conditions have changed in Illinois over the past four decades, and rabbits have responded differently to these changes across regions. Analysis of changes in the cottontail range over time may lead to predictive models of how alternative farm policies and programs might affect the cottontail in Illinois.

Cottontail young. Cottontail abundance has declined dramatically in Illinois in recent decades.

Another study is focusing on cottontail abundance and ecology in an area near Sibley in Ford County. Up through the mid-1970s, rabbit abundance was closely related to the amount of hay and small grains planted in this study area. More recently, however, rabbit abundance has become highly variable from year to year, with numerical trends less predictably associated with the amount of land devoted to hay and small grains.

To understand how rabbits are responding to changing habitat conditions, cottontails in the Sibley study area have been trapped (unbaited box trap), marked with ear tags, released, and then recaptured in many cases. From March 1990 through August 1992, there were 732 captures of 402 different rabbits. The mark-and-recapture study has provided information about the reproduction and survival of rabbits in the area.

Some of the trapped cottontails have also been fitted with miniature radio transmitters, which allow researchers to track the rabbits' movements. Monitoring these rabbits has provided information about their use of habitat and survival.

The intensive work in Ford County promises to further understanding of how

INSIDE

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rabbits have responded to changing agricultural land use and how future farming practices may affect rabbit abundance. Identifying emerging farming methods that would be relatively beneficial to the cottontail would be good news for rabbit hunters as well as local economies.

This research has been funded by the Illinois Department of Conservation and U.S. Fish and Wildlife Service using Pittman-Robertson funds for wildlife restoration.

Richard E. Warner and Phil C. Mankin, Center for Wildlife Ecology

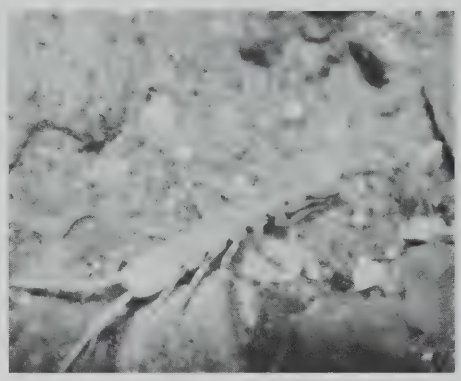
Survey researchers are studying the animals that inhabit Illinois' caves in relation to groundwater quality.

Cave Dwellers

More than 50,000 species are native to Illinois, including more than 29,000 species of insects and other invertebrates, thousands of plants, about 300 birds, more than 180 fishes, and 67 mammals. Among the native species that dwell on the surface (rather than underground), only two types of crayfish and two vascular plants are endemic (occur naturally only in Illinois). Thus, all but four of the tens of thousands of surface-dwelling species have been able to move or disperse across the Illinois border.

For species that live underground, however, moving across state lines apparently is not as easy. Of the more than 215 invertebrate species that live in caves or other groundwater habitats in Illinois, at least eight are endemic. These endemic species are special not only because they are unique to Illinois but also because they serve as natural biological indicators of groundwater contamination: the more contaminated the water, the less healthy the underground populations.

The subterranean endemics—three aquatic crustaceans (one isopod and two amphipods), three millipedes, and two beetles—are often found only in one or two caves or springs in Illinois. For example, one of the two endemic beetles (*Pseudanophthalmus illinoisensis*) is known only from one cave in Hardin



Endemic underground animals such as this blind, aquatic isopod are severely affected by groundwater pollution, such as that from pesticides and sedimentation.

County, and one of the amphipod species (*Caecidotea lesliei*) has been collected only once, from a drain tile located in McDonough County.

The geographic ranges of endemic subterranean species in Illinois have been strictly controlled by a number of factors, including geology and past events of isolation (that is, ice ages). The isolation of Illinois' endemic subterranean species began perhaps 20,000 years ago with the retreat of the Wisconsinan glacier, which led to warmer and drier conditions in what is now Illinois. Subterranean species, accustomed to cool, moist environments beneath the ice, were subsequently limited to inhabiting caves and other groundwater environments, from which it became difficult to disperse to other locations.

Protecting these groundwater environments from pollution is important for conserving the endemic subterranean species; it is also important for safeguarding human health because 75% of the nation's cities and 95% of our rural areas use groundwater as a source of drinking water. Nevertheless, pollution of cave streams and other groundwater sources has become more and more evident, threatening human health and well-being. Despite legislative efforts to protect our precious natural resources, sewage, industrial wastes, agricultural fertilizers, pesticides, and other substances toxic to humans have been found in Illinois' groundwater.

Populations of endemic cave invertebrates and other subterranean aquatic life can be thought of as "biological barometers" that provide warnings about the deteriorating quality of our groundwater resources. The current condition of our groundwater is reflected in the fact that the isopod and one of the two amphipods endemic to caves and

oundwater habitats in Illinois are listed
endangered species by the Illinois
dangered Species Protection Board.
rther monitoring of populations of
demic and other species of aquatic
oterranean invertebrates will aid
entists in determining the extent and
iousness of groundwater pollution.
ch information is vital for protecting
precious water resources as well as
own health.

ne Gardner, Steve Taylor, and Jean
ejca, Center for Biogeographic
formation

mpling Fish in Lakes

w many fish are in a particular lake?
hat size are the fish? What species are
y? These are questions asked by
heries managers responsible for Illinois
es.

To sample fish in lakes, biologists may use a wide variety of equipment, such as seines, gill nets, trap nets, and electrofishing equipment. The typical seine used in lakes is about 25 feet long and 4 feet deep. To use the seine, one person stands at each end holding poles called brails onto which the seine is attached. Usually, one person wades straight out from shore into shallow water and walks around in a quarter circle back to shore, thus trapping fish in the seine. Obviously, seines only catch fish that live in the shallow areas near shore or that happen to be there at that moment. This includes many species of minnows and the young of larger species. Because the seine can only be used in water shallow enough for wading and in areas without snags, this gear selectively captures species and sizes of fish that live in these areas. As it turns out, each of the gears used by fisheries biologists is selective in a certain way.

Survey researchers have examined the selectivity—in terms of capture efficiency—of several gears, with special emphasis on electrofishing because it can be used in a variety of habitats. Typically, boat-based electrofishing involves a flat-bottomed boat 16–20 feet long equipped with a generator for power and several electrodes mounted on long booms that extend in front of the boat (see photo). The biologist maneuvers the boat along the shoreline, and fish are temporarily stunned when overtaken by the electric field. The fish are netted, held in live wells, and then weighed, measured, and examined for other information.

Fish caught by electrofishing are rarely hurt. In fact, biologists take special care in handling these fish because any injury may bias the results of their study.

at-based electrofishing typically involves a flat-bottomed boat 16–20 feet long equipped with a generator for power and several electrodes unted on long booms that extend in front of the boat.

As with seining, electrofishing is selective for certain species and sizes. To examine this bias, Survey investigators conducted several experiments in ponds, reservoir coves, and small lakes that were being drained. In each of these areas, fish were sampled with electrofishing gear, marked, and then returned to the water. Next, as many fish as possible were captured by either draining the ponds or by using different sampling gears that are more efficient but also more laborious.

The proportion of captured fish that had been previously marked can be used as a gauge of the efficiency of the electrofishing gear. By examining the sizes and species of marked fish in relation to the sizes and species later captured, one can see what kind of bias results from using electrofishing.

The Survey studies found that the main factors influencing the efficiency of electrofishing sampling were water depth, the percentage of the water surface that was covered with aquatic vegetation (which affects visibility), and the length of the fish (very small and very large fish are more difficult to catch than fish of intermediate sizes).

A good example of this bias was found with largemouth bass, one of the most popular sport fish in Illinois. Under ideal conditions of shallow water (0.5 meters deep [about 1.5 feet]) and no aquatic vegetation, electrofishing captures approximately 22% of the fish that are 30 cm (12 inches) long. Under these same conditions, one catches only about 11% of the fish that are 40 cm (16 inches) long. Efficiency is even lower in deeper water with more vegetation. For example, in water 1.5 meters deep with 50% vegetation, efficiency drops to about 7% and 3% for 30-cm and 40-cm fish, respectively. In addition, capture efficiency decreases as the size of fish falls below 30 cm.

Why is this information important? First, management biologists often look at trends in populations over time to assess the sustainability of a fishery. If a lake is sampled during one year when vegetation is thick and then during another year when there is little vegetation, the results will show different levels of bias, and the samples will not be comparable.

Second, managers and researchers often compare fish populations in different lakes. If one lake is deep and a second shallow, the sampling efficiency will differ greatly, and the results of these studies will not be comparable. When we know the capture efficiency of electrofishing, we can estimate the actual populations from our samples, thus accounting for changes in conditions that affect sampling efficiency. This more accurate information gives managers and researchers a more meaningful tool for managing and investigating the aquatic resources of Illinois.

Douglas J. Austen and Peter B. Bayley, Center for Aquatic Ecology

Searching for Rare Plants

Of the approximately 3,200 types of plants that grow wild in Illinois, roughly 2,200 are native to the state. About one in six of these native species is rare—that is, considered endangered or threatened. Endangered plants are those in danger of extinction in Illinois, and threatened plants are those likely to become endangered within the foreseeable future. Presently, 22 plant species historically known to have been in Illinois are thought to no longer occur in the state, and an additional 40 plants have not been seen in Illinois for more than 20 years.

It is important to know the location of rare plants to prevent their loss through continued destruction of natural habitats.

Several factors have contributed to the rarity of some of these native plant species. One is the destruction of natural habitats by urbanization, expansion of agricultural lands, and other types of land development. Illinois, in fact, ranks second in the nation in the percentage of natural habitats lost. Other factors include competition with nonnative plants, commercial exploitation, and the fact that some of the species are at the edge of their natural distribution in Illinois (and are thus perhaps only marginally well-suited for living in Illinois).

It is important to know the location of these rare plants to prevent their loss through continued destruction of natural habitats. These rare plants are a part of Illinois' heritage and provide information about the state's natural environment. They provide this information through their specific environmental growing requirements, such as wet-mesic prairies, fens, sand prairies, sand savannas, limestone ledges, sandstone cliffs, hill prairies, acid lakes, calcareous lakes, cold-water lakes, rich mesic forest, and many others.

Searching for rare plants requires a knowledge of the state's plants, access to historical dried plant collections in herbaria, botanical literature, maps, and most of all the patience to make a thorough search of potential sites. The most vital tool in locating a certain plant is experience. Once you see a particular plant growing in its natural habitat, you gain insight into its growth habit, what plants it generally grows in association with, and its natural community requirements; this insight enables you to predict additional areas where it may be found. If firsthand experience is lacking, you can talk with someone who has seen the plant growing in its natural habitat, or perhaps the individual will even take you to the site so you can develop your own ideas about its habitat requirements.

Herbarium collections are a valuable source of information on plants. More than 500,000 plant specimens have been collected in Illinois and are deposited in various herbaria throughout the state. The earliest recorded plant collection in Illinois dates back to 1795 and was by André Michaux, a French botanist. Such

ois Beach State Park, the natural habitat of a threatened plant called the sea rocket.

sea rocket.

rds provide a historical account of
ts collected in Illinois. The label on a
arium specimen will provide
rmation on where the plant might
n be found and the time of year when
earch should be made.
Botanical literature provides addi-
al valuable information, such as
ht of the plant, habitat preference,
nguishing characteristics, flower color, flowering and fruiting times, and known geographic distribution. Because rare plants are sometimes difficult to distinguish, one must often consult several books to gain a greater insight on the plant to be located. Occasionally, some references provide incorrect information about a plant's growth and habitat requirements; this is especially true of the little-known rare plants.

Other sources of information, such as state maps, soil maps, topographic maps, gazetteers, and aerial photographs provide greater detail and extremely valuable information for plant searches. As maps continue to improve in detail, so does the information found on plant specimen labels. As a result, more recently collected specimens generally provide the best information about where to look for a particular plant. Soil maps also provide excellent clues about where to search. Plants have specific growth requirements, and many can be located by searching for specific soil types. In some states, rare plants are listed according to soil type and habitat.

It is necessary to visit more than one site when looking for a specific plant because the site may not appear as expected or the habitat may have been destroyed. When the plant's preferred habitat is located, you may need to spend several hours or even all day looking for the plant, and you should look for as many of the habitats in the surrounding area as possible. For example, rare plants on hill prairies most likely have not been found on all hill prairies; they may be located only in specific places such as on west-facing slopes. Although slight habitat differences may seem insignificant, they are often very important for rare plants. Because plants vary considerably in their requirements for growth, reproduction, and means of dispersal, some plants may be found in only 10% or fewer of the habitats where they might be expected to be found.

It should be noted that taking a rare plant from its location is prohibited without written consent of the landowner. The sale of endangered or threatened plant species is also prohibited.

Loy R. Phillippe, Center for Biodiversity

New Educational Publication

Wetlands are the subject of a new educational publication from the Survey. Intended primarily for use in middle school classrooms, *Wetland Wonders* provides teachers with necessary background information relating to wetlands and includes detailed descriptions of 12 educational activities for students. Some activities rely on student handouts, and copies suitable for reproduction are included.

The publication comes with a set of 20 high-quality color slides, as well as a sample copy of a poster depicting 31 wetland plants and animals. Suggestions for how to use the slides and poster in conjunction with the text are included in the publication; an appendix provides commentary on each slide.

Issued as Special Publication 14, *Wetland Wonders* is available for $7. This price covers the cost of the supplementary materials, including the slide set. To obtain a copy, write to Distribution Center, Illinois Natural History Survey, 607 East Peabody Drive, Champaign, IL 61820, or call 217-333-6880.

Species Spotlight

Gray Fox

On a warm spring day the trees are beginning to bud, and the migrating warblers have returned. While scanning the trees to identify each colorful warbler, you notice something large and grayish—too big for a bird or a squirrel and too gray for a bobcat. Closer inspection with the binoculars reveals a doglike mammal.

After consulting a little-used field guide that happens to be in your day pack, you determine that the "dog-in-the-tree" is, in fact, a gray fox—the only fox with climbing ability. Using the sharp, curved claws on their forepaws, gray foxes grab hold of bark and boost themselves up with their hind paws. They use this climbing ability to ambush prey, obtain food such as bird's eggs or nestlings, escape enemies, take refuge during the night, stand look-out, or merely laze away the day.

Related to the coyote and wolf as well as the red fox, the gray fox, *Urocyon cinereoargenteus*, has a pepper-and-salt coat and a long, bushy, black-tipped tail with a median black stripe. An animal of forests, bluffs, and river bottoms, the gray fox can be found throughout Illinois but is more abundant in the southern third of the state and near the Mississippi and Illinois rivers. Although gray foxes usually remain in wooded areas, they sometimes stray into brushy or wooded pastures. Because of their lower population numbers, nocturnal habits, and propensity to stay closer to hiding places and under cover, gray foxes are seen much less often than red foxes.

The gray fox is found throughout Illinois but is more abundant in the southern third of the state.

Although gray foxes prefer to eat rabbits, mice, or voles, they are omnivorous and will eat berries, fruits, acorns, and seeds as well as birds and insects. When food is abundant, they will stuff themselves and become very fat.

Dens, which are used throughout the year, are usually located beneath a log, in a hollow tree, or under a pile of rocks. The mating season is during the winter. After a gestation period of 53–63 days, the young, usually three to five pups, are born during April and May. Although the babies are born blind, by 11 days their eyes open, and by four months they are foraging on their own.

Gray fox populations in Illinois have likely suffered from the conversion of forestland to agricultural and other uses. Continuing change in the landscape means an uncertain future for the gray fox in Illinois.

Teacher's Guide to "The Naturalist's Apprentice" (facing page)

OBJECTIVE to identify characteristics that place mammals into major taxonomic groups called orders

SKILLS observing, comparing, classifying, synthesizing

VOCABULARY nocturnal, extirpated, order

MATERIALS glue or cellophane tape, multiple copies of "The Naturalist's Apprentice," scissors

COMMENTS Although many of the animals that are most familiar to humans are mammals, most mammals are seldom seen. In Illinois, most are either nocturnal or subterranean (live underground). Only one is considered a large mammal (white-tailed deer), and 68% are rat-size or smaller. Although several other large mammals once lived in Illinois—bison, elk, mountain lion, and bear—these have been extirpated from the state. The 62 species of Illinois mammals can be divided into seven major orders, which are the focus of this edition of "The Naturalist's Apprentice."

PROCEDURE **1**. Distribute copies of "The Naturalist's Apprentice."

2. Direct students to read the characteristics of each mammal order and choose the correct drawing to paste in the box. Students may color these pictures if they wish. *Correct answers: A. Chiroptera–bat, B. Rodentia–pocket gopher, C. Lagomorpha–cottontail rabbit, D. Carnivora–badger, E. Artiodactyla–white-tailed deer, F. Marsupialia–opossum, G. Insectivora–shrew.*

3. You may want to have students check with you before pasting their mammals into the order boxes.

4. After the mammals have been pasted in the correct boxes review the characteristics of the seven orders and identify each by its scientific name. Have students name other members of each of the orders. Note: The oppossum is the only member of the Marsupialia in Illinois.

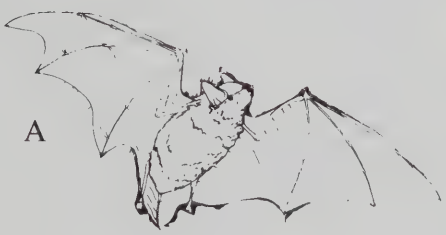
EVALUATION List the orders in this activity on the chalkboard, numbering them from one through seven. Ask students to count off in sevens. Each student then draws an imaginary mammal that fits the definition of the order that matches his or her number. The description in the box may be used, but the mammal should not be copied. Collect the drawings and redistribute them randomly and have each student identify the order to which the mammal he or she received belongs. The illustrator of each mammal may confirm or dispute this label.

aracteristics of Seven Main Orders, or Categories, of Mammals in Illinois

out the drawings from below and glue each in the correct box. You may color the drawings if you wish.

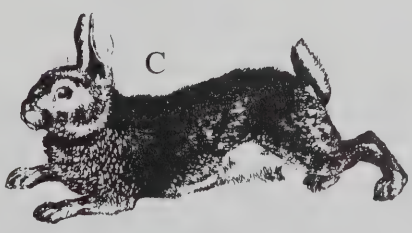
Order Marsupialia oes/foot; scaly tail; opposable umb on back foot	**Order Insectivora** small with pointed nose; tiny, beadlike eyes; 5 toes/foot	**Order Chiroptera** hand formed into a wing; thumb is free and has a claw
Order Lagomorpha ort, furred tail; large upper eth for cutting; large hind feet	**Order Artiodactyla** foot is hoofed; antlers may be present	**Order Carnivora** large canine teeth; clawed toes
Order Rodentia ge upper and lower gnawing eth; relatively small		

A



B

C



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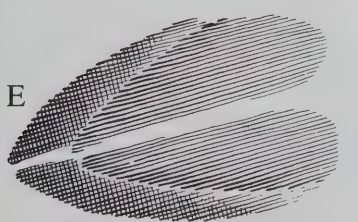


F

G

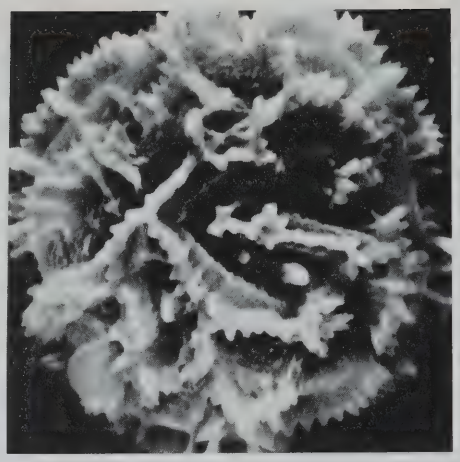
ıe Naturalist's Apprentice" presents educational activities for middle school students. Teachers are invited to photocopy this feature for classroom use.

Slime Molds

Slime molds are an interesting group of organisms with both plant and animal characteristics. One of the plant characteristics is the growth of spore-bearing fruiting bodies, which often have interesting forms. One species, for example, made Ripley's "Believe It or Not!" for being described as hair growing on wood.

The animal characteristics of slime molds are apparent when their spores germinate into amoeboid bodies that develop flagella, move, feed, and divide as do protozoa. These amoeboid bodies, called myxamaebae, fuse and form a plasmodium, a mass of protoplasm with many nuclei. Plasmodia vary in color and size, depending on the species. *Lycogala*, a common genus, is named for its coral-red to cream-colored plasmodium, which the ancients thought was wolf's milk and thus named with the Greek words *Lyc* (= wolf) and *gala* (= milk).

Plasmodia may be confined to their substrate (wood or ground, for example) or cover many substrates, and they can attain a size of several feet or more and



Ornamented spore of the slime mold Fuligo megaspora.

function as a giant amoeba. Just before the fruiting or spore-forming stage, the amoeba emerges from its substrate to appear on the surface. The "Texas Space Monster" that made headlines in 1972 was a large plasmodium bubbling up on lawns in Texas. Plasmodia feed by engulfing bacteria and other microorganisms found in or on the substrate and are regarded by many scientists as animals.

At maturity the plasmodia assume the shape of stalked or sessile sporocarps structures in which spores are produced. The spores, which may be pallid or a variety of colors, are generally globular, with a rather thick wall. They are exceptionally resistant to unfavorable conditions, including prolonged periods of desiccation. Sporangia (the cases in which the spores are carried) may have sterile threads called capillitia, which aid in spore dispersal.

Slime molds have been widely used in research. They can be grown on moist filter paper with oatmeal as a food source. The large plasmodia are used in cell physiology experiments, especially those on calcium and phosphorus metabolism and cell movement. The myxamaebae are often used as bioassay organisms. They can be used, for example, to evaluate the vitamin content of instant oatmeal, which may lose its B vitamins during processing. The myxamaebae (as well as the plasmodia) die quickly on a diet of vitamin B–deficient oatmeal.

J.L. Crane and J.D. Schoknecht (affiliate), Center for Biodiversity

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pulations of Forest Songbirds

ındances of many species of forest gbirds seem to be declining. Concern ıidespread that these declines are ous for neotropical migrants such as blers and vireos, which may face erse ecological conditions while eding in Illinois or while wintering in tropics. These conditions can include simple loss of habitat or more subtle cts associated with forest fragmenta- (the breaking up of continuous for- into smaller, isolated tracts). Forest mentation can lead to decreased food lability or increased rates of nest lation and brood parasitism. Thus, the blem of understanding, predicting, and venting further declines in songbird ulations is complex.

A basic and formidable challenge is etect declines while they are actually urring. Foremost, this problem ires acceptably reliable methods of mating abundances. For forest song- s, several methods have been devel- d. All these methods involve counting s by sight and, most importantly, by nd.

Wildlife populations are rarely static me or space, however, and problems e when attempting to separate this ckground variation" from unusual ds that signal a need for intensive y and conservation measures. In y cases, existing data are insufficient establishing whether a decline over, three years is unusual or within the nal bounds of change over time. versely, a short-term increase can ır within the context of a long-term ine.

Detailed studies of the nesting ogy of songbirds in Illinois forests

Trelease Woods, one of the sites in which bird populations are being evaluated.

are being conducted throughout the state to examine how forest fragmentation affects nesting success and population sustainability. A study was initiated in east-central Illinois in 1992 to evaluate long-term changes in the abundances of forest birds. Investigators in this study are censusing breeding birds in several woodlots and comparing the results with earlier records of birds in these areas. In addition, the earlier records, some of which span half a century, are being statistically analyzed to learn how abundances vary over long time periods.

The earlier records were generated by the late S. Charles Kendeigh (an avian ecologist at the University of Illinois), who developed a long-term database on the abundances of breeding birds in woodlots ranging from 24 hectares (about 60 acres) to more than 600 hectares. For some areas, notably the University of Illinois' Trelease Woods, the records extend from the 1920s through the mid-1970s. These data span a longer time period than those from nearly all other similar studies; census data for most of North America typically extend back only to the 1960s. Thus, analysis of the Kendeigh data should provide comparatively deep insight into the dynamics of avian populations.

INSIDE

♦

Wood thrush, a species that seems tolerant of forest fragmentation.

At least three years of new data will be required before meaningful comparisons of current and previous abundances can be made. Based on data from 1992 alone, however, it appears that some species have become more common whereas others have undergone dramatic declines. Although the relative abundance (that is, the proportion of all breeding pairs within an area) of neotropical migrants as a group has not declined appreciably, certain species may have become locally extinct.

Overall, the number of bird species breeding within the woodlots has remained relatively constant. Certain species, such as the wood thrush (*Hylocichla mustelina*), seem tolerant of severe forest fragmentation whereas others, such as the ovenbird (*Seiurus aurocapillus*), have essentially been absent from small woodlots throughout most of the 20th century.

Jeffrey Brawn, Center for Wildlife Ecology

Canola Insect Pests

Drivers accustomed to the "corn on one side, beans on the other" landscape along highways and rural roads in Illinois have been intrigued in recent years by the sight of fields of turniplike plants with spires of delicate pale yellow flowers. A new oilseed crop, canola, is gaining a foothold in the Midwestern agricultural lineup. Canola (Canadian oilseed low acid) is a type of rapeseed specially bred to improve its qualities as a vegetable oil for human consumption and as meal for animal feed. Rapeseed is a member of the crucifer or mustard family (Brassicaceae).

Interest in canola and other rapeseed has climbed rapidly in the past 20 years so that these now account for 12% of world oilseed production. With the rise i popularity of canola oil because of its lo saturated fat content, American imports of this oil from Canada, the leading producer, have more than doubled since 1985. Concurrently, domestic productio has jumped from 6,400 acres harvested i 1985 to approximately 186,000 acres planted in 1992. Development of varieti suitable for winter and spring planting has expanded canola production into the Southeast, Midwest, Northern and Central Plains, and Pacific Northwest. Only winter canola (primarily *Brassica napus*) is grown in Illinois, and annual production here has held fairly steady at 4,500 to 6,500 planted acres since 1989.

As with any new crop, there is stron interest in determining what pest problems may develop as crop acreage expands. Because of canola's short history in this country, there is little published information on insects associated with t crop in the Midwest. Consequently, entomologists and extension specialists with the Natural History Survey and University of Illinois have been conduct ing periodic field surveys, checking out reports from county advisers and seed company representatives about specific pest problems, and developing assessments of which species could be of greatest concern in this region.

Aphids and some species of Lepidoptera (butterflies and moths) are likel to be at least occasional pests of canola Illinois. The cabbage aphid (*Brevicoryn brassicae*), turnip aphid (*Lipaphis erysimi*), and green peach aphid (*Myzus persicae*) are often found on terminals o canola in the flowering and ripening stages in late spring. Aphid feeding may kill some terminals but should not seriously affect yield. Damage is more likel however, when fall weather conditions favor development of large populations on young plants. Heavily infested plants can be killed outright or so severely weakened that they become vulnerable t

interkill. Populations of several hundred phids per plant brought about the emergency use of insecticides in some fields in utheastern and southern Illinois in 1989.

Two species of Lepidoptera have used minor problems. In October 1988, known larvae at densities of 3 to 10 per uare foot were found attacking canola d alfalfa in parts of west-central Illinois. rvey entomologist George Godfrey entified them as the clover cutworm *iscestra trifolii*), an insect not previsly found in Illinois. In March 1989, rvey entomologists discovered additonal fields in southwestern Illinois with ant damage linked to the clover cutorm. Damage exceeded 9% in one insively sampled field. The apex of maged plants was destroyed or severely rdled, causing death or loss of apical minance and subsequent growth of teral stalks (see photo). Seed production these laterals would be delayed comred with that on undamaged plants. his could reduce the quality of harvested ed because of the presence of green ed, which reduces oil quality.

Survey entomologists also observed e invasion of some canola fields by myworms (*Pseudaletia unipuncta*) in 989. Large larval populations caused oblems in ripening canola for some owers in southwestern Illinois, especially in fields adjacent to winter wheat. rmyworms developed in wheat fields d then invaded canola, chewing into the ds and destroying seed.

Other Lepidoptera such as the amondback moth (*Plutella xylostella*), a ucifer specialist, are pests of canola in her regions and could damage the inois crop under favorable conditions. rvae feed on foliage and strip the epirmis from green pods. During field surys, Survey entomologists have found w numbers of *Plutella* larvae on canola the fall. With the use of pheromone aps (see photo), they have also determined that this insect can complete a neration on canola in the spring before oving into summer vegetable plantings. ecause the diamondback moth is

Survey researcher showing diamondback moths in a pheromone trap.

resistant to several insecticides, special control strategies may be needed if it develops into a routine pest of canola.

The cabbage seedpod weevil (*Ceutorhynchus assimilis*), which causes serious problems in canola in other regions, is another potential pest in Illinois. Larvae develop inside the pods and consume seeds. Feeding damage by adults can reduce seed dry weight, oil content, and germination. Low populations of this weevil were noted in some fields in southern Illinois in 1989, and seed injury was reported in 1990 in parts of southeastern Illinois.

At present, no insect species should be considered a major pest of canola requiring routine control with insecticides in Illinois. Problems to date have been very minor, affecting only a few fields or parts of fields in portions of the state. Low pest populations are best left to natural regulation by predators, parasitoids, and pathogens. Growers concerned about possible insect pests should check their fields in fall and early spring to monitor the incidence of aphids and larval Lepidoptera. Fields should also be examined during flowering and pod set stages in late spring to determine whether

Probable clover cutworm damage to canola.

damaging numbers of Lepidoptera, seedpod weevils, or aphids are present. Extension advisers should be consulted if growers find insect populations they believe may cause significant crop damage. *Catherine Eastman and Hassan Oloumi-Sadeghi, Center for Economic Entomology (with input from Kevin Steffey, Noel Troxclair, Jr., and Rob Koethe)*

Ferne Clyffe State Park

Just beyond where the Illinoian glacier stopped its southward advance, massive outcroppings of ancient sandstone and shale bedrock stand exposed and weathered in the greater Shawnee Hills. Most prominent is the Pennsylvanian sandstone, deposited by a warm sea some 270–310 million years ago. It escaped burial by glacial soil and rock deposits that filled in much of the landscape to the north. The land was untouched by the ice, but not unaffected. Canyons that were originally cut by torrential glacial meltwaters have, over time, been widened and deepened by the meandering of clear, rock-bottomed streams. These slow reminders of the past have also carved out shelves and steps and the so-called caves or shelter bluffs in the canyon walls. The caves are actually undercuts in the sandstone, with large overhanging ledges forming the ceilings. Ferne Clyffe State Park in Johnson County has excellent examples of sandstone canyon, ledge, and cliff communities. The park covers 1,100 acres and contains unique rock formations, gorges, canyons, shady dells, shelter bluffs (caves), and even an intermittent waterfall.

By the early 1900s, Ferne Clyffe was already a popular place to visit. Classified by the state as a natural scenic area, it was named for its abundance of ferns. On Sundays, 20 cents would buy transportation on the morning train from Goreville and admission to the park. At that time, the 140-acre park was owned by Miss Emma Rebman, a schoolteacher as well as the Johnson County school superintendent. During her stewardship, Miss Rebman took great pleasure in naming various points in the park, including Hawk's Cave and Round Bluff. In 1949, the state purchased the original 140 acres.

Hewn by wind and water, the sheer cliff of Hawk's Cave forms a vast overhang 150 feet long and nearly as high. From the cave one is afforded a fine view of the early spring upland forest community of the park. The floor of the overhang may appear to be nothing more than a layer of fine dust, something to linger in without shoes and socks. Close observation of the dust, however, reveals patterns of life. Circular depressions are antlion pits dug by larvae of the insect family Myrmeleontidae. Each pit has a predatory antlion larva covered by dust and lying in wait at the base. Small insects fall into the pit, cannot climb out because of the loose soil, and become a meal for the large jaws of the antlion. Sinuous patterns on the floor indicate the passing of various species of snakes that spend their winters in the cave. During the first half of this century, snakes would hibernate by the thousands among the rocks and then break from their dens on warm sunny days in April. Today the snakes are much less numerous, and the once-continuous brown rippling wave of snake migration is clued only by a few sinuous patterns in the fine dust.

At the base of the cliff, where water dripping from the overhang has formed a ribbon of moisture, may be be found an uncommon relative of the prairie shooting star—French's shooting star, *Dodecatheon frenchii*. Named for George Hazen French, an early biologist at Southern Illinois University, this diminutive plant was originally thought to exist in a band only 10 miles wide across southern Illinois, but isolated populations have since been found in Indiana, Missouri, Arkansas, and Kentucky.

A massive sandstone outlier named Round Bluff by Miss Rebman stands like an island, separated from the other bluffs of the park. Round Bluff, an Illinois Nature Preserve, contains many of the 700 species of plants found in the park. A one-mile trail around the bluff provides

Hawk's Cave, one of the most popular places to visit in the park.

Practical Information

Ferne Clyffe State Park is in Johnson County approximately 1 mile south of Goreville and 12 miles south of Marion on Illinois Route 37. About 3.5 hours south of Champaign by car, the park is easily accessible from both I-57 and I-24, which have clearly marked exits. Camping facilities are available. For more information, call (618) 995-2411.

Spicebush swallowtail caterpillar.

Carolina box turtle.

an excellent glimpse of the preserve. In the spring, as one descends into the ravine on the northern side of the bluff, wonderful assemblages of wildflowers and ferns line the trail—mayapple, yellow trout lily, jack-in-the-pulpit, and squirrel corn. The latter covers the wood's floor with lush, feathery foliage. Large sandstone blocks have separated from the canyon walls and create blind alleys and narrow passages within the forest. Each imperceptibly slides toward the valley floor, assisted by gravity, the push of freezing ice, and growing tree roots. The tops of these blocks are isolated islands, many never experiencing human footprints. Here are miniature forests of waterleaf, spring beauty, trout lily, phlox, and hay-scented fern. Saxifrages, mosses, and various species of ferns clothe the face of the bluff in a verdant carpet. Farkleberry and red cedar are common shrubs on the bluff top, and spicebush and sassafras are found in the moister areas at its base.

The most common butterflies are likely to be the spicebush and eastern tiger swallowtails. Spicebush caterpillars can be found in rolled-up leaves on both spicebush and sassafras. When small, the caterpillars resemble bird droppings; larger larvae are mimics of the rough green snake! Visitors with a sharp eye may spot walking sticks on the vegetation, blue-throated eastern fence lizards scampering over fallen trees, or a Carolina box turtle plodding over the ground.

Vegetated bluff face.

French's shooting star.

With its valleys, dells, canyons, brooks, plants, and animals, Ferne Clyffe State Park offers visitors infinite variety. Ten developed trails total 15 miles in length. One of the easier trails, the Rebman Trail, is dedicated to the area's former owner. Without her foresight, the park would not be ours to enjoy today.

Text and photos by Michael Jeffords and Susan Post, Center for Economic Entomology

Species Spotlight

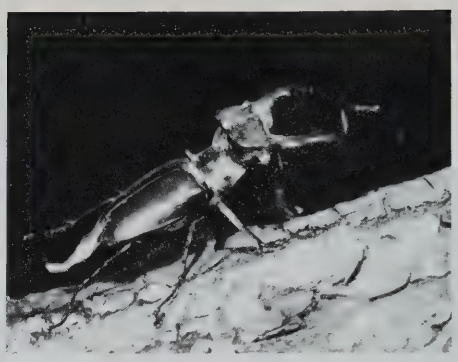
Giant Stag Beetle

In the deep woods of southern Illinois on a warm June night, a clash of titans occurs: two giant stag beetles duel on the gnarled surface of an ancient oak. Although these creatures are diminutive in human terms (about 2 inches long), the intensity of their combat equals the brain-rattling collisions of bighorn sheep or the concussion of sword against sword of the knights of old.

The male giant stag beetle, *Lucanus elaphus*, can be recognized by its large curved mandibles, often half as long as the body and branched like the antlers of a stag. Females have shorter but much more powerful mandibles.

Stag beetles (Family Lucanidae) are members of the order Coleoptera, the largest order of insects. In fact, 40% of the known insects are beetles, and one of every four named species of organisms is a beetle!

Perhaps the most distinctive feature of beetles is the structure of their wings. Most adults have two pairs. The front pair (called elytra) are hard or leathery and of little use in flight. When a beetle is at rest, the elytra meet in a straight line down the back. The hind wings, which are used for flight, are membranous and usually longer than the elytra; when at rest, they are neatly folded under the elytra, which serve as protective sheaths. In Greek, coleoptera means "sheath wing."



Male giant stag beetle.

Male stag beetles are extremely pugnacious and often battle with each other for the favors of the opposite sex. A typical encounter, which usually takes place on a vertical surface such as a tree trunk, might go something like this. As the two males approach each other, their mandibles are opened as wide as possible and both beetles appear to stand on tiptoe. When within reach of one another, each male will try to grab the other in its mandibles and lift it off its feet. If one is much larger, it may soon lift the smaller male; but with evenly matched pairs, the males may struggle for some time. Eventually, one male will either knock the other from the surface or "lean back" with the smaller male clasped helplessly in its mandibles and then merely drop the beetle to the ground. Although this does not hurt the smaller beetle, it establishes the dominance of the larger male, who then makes off with the female that was nearby. To the victor goes the spoils!

Adult stag beetles are usually found in the woods, where they feed on honeydew or on the exudations of leaves or the bark of trees. The females lay their eggs in crevices in bark near the roots. The larvae, which are C-shaped and dull white or cream-colored and similar to the white grubs found in lawns (although much larger), live in or beneath decaying logs and stumps and feed on the juices of wood in various states of decay. The beetles' ability to feed on decaying material helps to recycle a large amount of this material for reuse by other organisms.

Teacher's Guide to "The Naturalist's Apprentice" (facing page)

OBJECTIVE to learn about various types of animal behavior

SKILLS observation, deduction

MATERIALS copies of "The Naturalist's Apprentice"

COMMENTS Animals are distinguished from other types of organisms primarily because of their behavior. They are free to move about, to explore their environment, and to manipulate their surroundings. Many types of behavior are associated with food gathering. Other behaviors come about when animals strive to reproduce, protect themselves from predators, or deal with the rigors of the environment. This edition of "The Naturalist's Apprentice" introduces students to the following types of behavior: combat for females, aggregation, territoriality, parental care, prey capture, migration, tunneling, grooming, food cacheing (storing for later use), and mate calling.

PROCEDURE **1**. Distribute copies of "The Naturalist's Apprentice."

2. Have students match the listed behaviors with the appropriate drawings. Students may color the pictures if they wish. *Correct answers: A6–Canada geese migrating south; B10–toad calling for a mate; C5–water scorpion capturing a fish; D3,10–cricket calling for a mate or warning other males away; E4–male giant water bug taking care of its mate's eggs; F10–songbird calling a mate; G9–honeybee storing honey for later use; H3–yellow-headed blackbird warning other males away from its territory; I8–wild rats grooming; J5–barn swallow capturing insects; K1–bighorn sheep fighting for mating privileges in the herd; L7–mole digging through soil in search of worms; M7–spadefoot toad dug in to hide from predators; N2–garter snakes gathering together to spend the winter in a protected place; O4–woodpecker feeding its young; P2–overwintering bats in a cave; Q1–male unicorn beetles fighting.*

3. After students have completed the exercise, discuss their results and provide the students with the information presented in the preceding answer section.

EVALUATION As a classroom activity, have students list other types of animal behavior. Use this list of behaviors generated by the students, as well as the list presented in this activity, and have students list various types of animals that demonstrate each of these behaviors. For example, both humans and scorpions demonstrate parental care. (Scorpion females carry their young around on their backs).

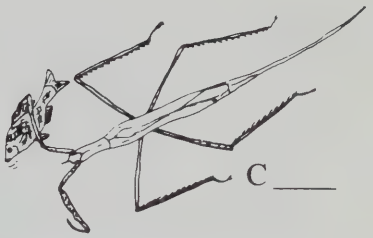
Animal Acts: Identifying Various Types of Animal Behavior

Match the behaviors with the proper drawings. Each behavior may be illustrated by more than one drawing.

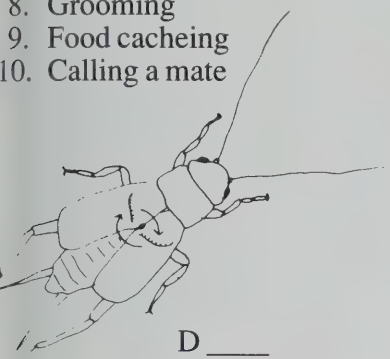
1. Combat for females
2. Aggregation
3. Territoriality
4. Parental care
5. Prey capture
6. Migration
7. Tunneling
8. Grooming
9. Food cacheing
10. Calling a mate

A ____

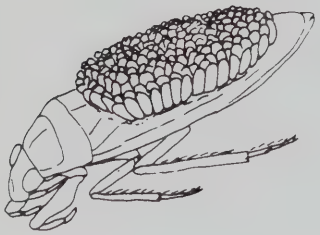
B ____



C ____



D ____

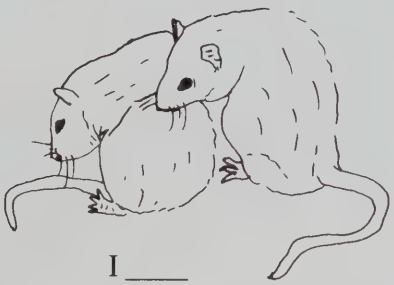


E ____

F ____

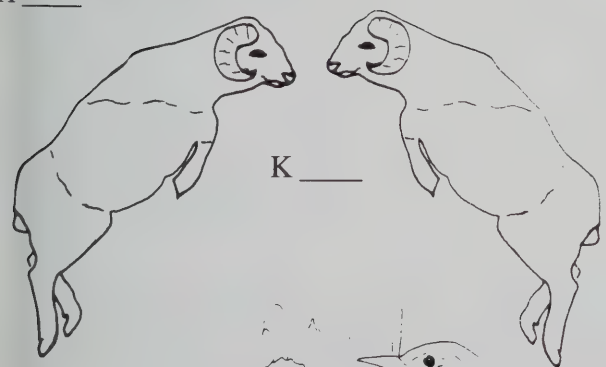
G ____

H ____



I ____

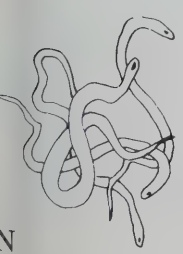
J ____



K ____

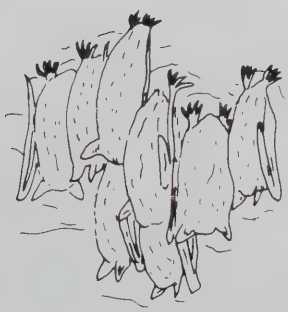
L ____

M ____



N ____

O ____



P ____

Q ____

"The Naturalist's Apprentice" presents educational activities for middle school students. Teachers are invited to photocopy this feature for classroom use.

Assessing Environmental Trends

Governor Jim Edgar has asked the Natural History Survey and other units within the Department of Energy and Natural Resources to report biennially on critical trends affecting the environment of Illinois. The first report is due in fall 1993. To help prepare this report, Survey researchers are now sifting through volumes of information, such as the following:

- Although the prairie chicken was found in 92 of 102 counties in Illinois in 1905, today it is found in only 3.
- Illinois has enough coal to satisfy its present rate of consumption for 1,000 years, enough oil to meet its own demand for only 1 year, and enough topsoil to last 150 years at the present rate of erosion.
- Eighty percent of Illinois' 35 million acres is cultivated. Of the original 20 million acres of prairie, only 2,300 acres remain.
- From 1930 to 1990, the human population of Illinois grew 64%, from 6.7 to 11 million, and the motor vehicle population grew 470%, from 1.4 to 8.1 million.
- Although deer had become nearly extinct in Illinois by 1930, about 600,000 deer now roam the state.
- Thirty-two percent of the 3,100 vascular plant species now found in Illinois are not native to the state.
- Illinois produces 7% of the world's corn, 9% of its soybeans, and 1% of the carbon dioxide produced by human activities. The atmospheric buildup of carbon dioxide contributes to global warming.

Assimilating many disparate pieces of information into a definition of "environmental quality," and deciding which environmental issues are most critical, is challenging because of the large number and variety of factors involved, as the above list suggests. There are also several levels at which environmental well-being can be considered. The highest plane of analysis addresses ecosystem health and sustainability. An intermediate level considers changes in populations of particular species or in the condition of habitats. A more basic level of information and analysis relates to specific physical measurements, such as the amounts of certain types of pollution that are released into the environment. All of these levels of analysis will be considered when preparing the biennial report cards.

The environmental reports will help government officials and citizens determine environmental policy for Illinois, and the reports will help document progress, or lack thereof, in addressing environmental issues. The authors of the forthcoming fall 1993 report expect some good news (the recovery of deer populations, for example) as well as bad (such as continued soil loss).

Robert A. Herendeen, Center for Aquatic Ecology

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REPORTS

March/April 1993 No. 320

Corridors for Tomorrow

The first European settlers to arrive in Illinois encountered a fabulous natural landscape. The northern part of the state was a mosaic of prairies, wetlands, forests, and savannahs. Along the magnificent natural shoreline of Lake Michigan were beaches, sand dunes, swales, and cliffs dissected by wooded ravines. The central part of Illinois was primarily tallgrass prairie, spectacular in all seasons, dotted with isolated woods known as prairie groves. Toward the west and south the prairies gave way to mature forests and tall cliffs of sandstone and limestone. In the extreme southern part of the state were swamps filled with giant bald cypress and tupelo trees, reminiscent of areas much farther south and lacking only Spanish moss and alligators. What a sight this original and wild Illinois must have been!

The ecological diversity of Illinois is reflected in the large number of native species. A recent compilation by Susan Post of the Natural History Survey estimates that more than 54,000 species are native to Illinois, including 2,574 plants, 20,000 fungi, 28,000 insects and relatives, 374 mollusks, 187 fishes, 39 amphibians, 59 reptiles, 297 birds, and 67 mammals.

The rapid settlement and subsequent economic development of Illinois has dramatically affected the biology of the state. Most of this development has been based on the conversion of native habitat to agricultural fields and areas for industry and urban expansion. Logging, mining, and pollution have degraded the remaining natural habitats. Regrettably, only a tiny fraction of the original prairies, forests, savannahs, and wetlands have survived. Illinois ranks 49th (Iowa is 50th) in the percentage of land in its original form.

One facet of the Corridors for Tomorrow project is the installation of roadside bird perches, intended especially to attract raptors, such as hawks. Attached to the perches are pieces of wood that provide nesting habitat for mud daubers and bees.

The loss of habitat has caused not only the extinction of some species but also a drastic reduction in the abundance of most native species. Currently, 497 species, mostly plants and conspicuous animals, are listed as endangered in Illinois, and it is estimated that at least 115 species have already been lost from the state.

In a project named Corridors for Tomorrow, the Natural History Survey is investigating ways to use right-of-way along Interstate highways in Illinois to provide much-needed habitat for native species. The Illinois Interstate highway system is the third largest in the nation, with about 1,900 miles of corridors, 370 interchanges, and 31 open or proposed rest areas. Associated with this system is about 135,000 acres of land that is owned by the state.

Funded in part by the Illinois Environmental Protection Fund Commission, Corridors for Tomorrow involves the development of guidelines for

INSIDE

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planting state-owned lands along the Interstate with native species that will be allowed to grow undisturbed. (The Illinois Department of Transportation will do the actual planting.) With traditional highway management practices, most right-of-way has been planted with non-native species, and management has emphasized cyclic patterns of disturbance, such as herbicide use and mowing.

Although the ultimate goal of Corridors for Tomorrow is to re-create or at least simulate naturally occurring habitats, it is necessary to use landscape design to adapt to the conditions found along highways. Biologists can determine the kinds of habitats they want to re-create, but they generally do not have the expertise to develop and complete landscaping plans and specifications. Collaborating on this aspect of Corridors for Tomorrow are Terence Harkness, a faculty member of the Department of Landscape Architecture of the University of Illinois, Matt Torgerson, a graduate student in Landscape Architecture, and Tom Brooks of the Survey.

Landscape designs are being developed to provide better interpretations of biodiversity to the motorist than would strict re-creation of native habitats. For example, a realistic prairie restoration 30 feet wide is not very dramatic at 65 miles per hour. A way to help interpret a prairie for the motorist is to dissect it and show the component parts on a large scale. The components could be presented in mass plantings of showy species at intervals along the corridors. This presentation would provide an attractive public educational opportunity.

How You Can Help with Corridors for Tomorrow

You can help us with Corridors for Tomorrow! At selected sites along Interstates in central Illinois, we have installed bird perches, especially to attract raptor birds, such as hawks. These perches are 12 feet tall, with a crossbar at the top (see photo on previous page). Attached to the pole are two wooden objects to provide habitat for nesting insects—small "eaves" and a block about 4" x 4" x 8"; the former is for mud daubers, and the latter is for native solitary bees. If you see a bird using these perches, please write to Ken Robertson at the return address shown on the back of this newsletter.

Bird Perch Sites

I-55	
Edwardsville exit	SE quad
Litchfield exit	SE quad
Carlinville exit	NW quad
Glenarm exit	SE quad
Funks Grove rest area	NE, on N-bound exit ramp
S of Shirley exit	E side of N-bound lanes
I-255	
Intersection with I-270	NE quad
I-57	
Salem exit	NW quad
Edgewood exit	SW quad
N of Mattoon exit	W side of S-bound lanes
N of Leverett Rd. exit	E of N-bound lanes
Paxton exit	NW quad
Manteno exit	NW quad
I-70	
Marine exit	NE quad
Greenville exit	SE quad
I-72	
Riverton exit	NE quad
Mechanicsburg exit	SW quad
Oreana exit	NE quad
Oreana exit	SE quad
E of Argenta exit	S side of E-bound lanes
Monticello east exit	SE quad
Highway 10 exit	NW quad
Highway 10 exit	SE quad
US 36	
Bluffs exit	NW quad
Jacksonville exit	NW quad
Ashland exit	NW quad
New Berlin exit	NW quad
Chatham exit	NE quad

The overall design of highway plantings needs careful consideration to include species that cover the complete range of flowering period, from early spring to late fall, with a broad fruiting period. Plants are largely dependent on insects for pollination and on a wide variety of animals for seed dispersal. A phenologically complete habitat provides optimum conditions for the greatest diversity of native insects, birds, and small mammals.

Prairie plantings in highway rights-of-way will provide habitat for many grassland birds, wintering grounds for upland gamebirds, and a seed source for migrating birds. Numerous prairie plants will also provide pollen, nectar, and food resources for native bees, wasps, butterflies, and other insects. Native trees and shrubs will provide additional foraging habitat for breeding birds in nearby forest and important stop-over points for migrating birds.

Perhaps the most practical human benefit from these revegetation efforts in Illinois will be an improvement in the quality of our environment. We are all concerned about how human activities are modifying the very nature of our world. Climatic changes, toxic pollution, erosion, diminishing water quality, food shortage, and depletion of our non-renewable energy resources affect everyone's life. Diverse highway corridors will act as buffers between agricultural and urban development and the existing native habitats of Illinois. These revegetation buffers will soak up pollution, capture and store carbon dioxide, filter and dilute dust and exhaust pollution, retard erosion and loss of top-

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soil, and help prevent siltation of our streams, rivers and lakes. Reduction in highway maintenance, including mowing and herbicide application, will save money and significantly reduce our state's use of energy and toxic chemicals. Highway landscaping with native species will also contribute to the scenic beauty of Illinois and leave motorists with a favorable, if not nostalgic, image. Finally, an Illinois revegetation program will help activate local interest in environmental issues and stimulate grassroots efforts for an environmentally sound Illinois.
Kenneth R. Robertson, Center for Biodiversity

Floodplain habitat of cerulean warblers in Shawnee National Forest.

Habitat Preferences of the Declining Cerulean Warbler

In 1871, ornithologist J.A. Allen considered the cerulean warbler to be the most common warbler of midwestern woodlands, and in 1889, Robert Ridgway wrote that it was "by far the most abundant of the summer-resident members of the family in Illinois." Today, however, most Illinois birdwatchers consider a glimpse of this beautiful sky-blue and white warbler to be a rare treat. Significant breeding populations of the cerulean warbler (*Dendroica cerulea*) are now located in only a few of the more extensively forested areas of the state.

Downward trends in cerulean warbler populations have been documented throughout most of this bird's breeding range. Of all neotropical migrant species, the cerulean warbler is thought to have one of the fastest-declining populations, suffering a population loss of 3.4% per year in the United States from 1966 through 1987. In 1991, this species was listed by the U.S. Fish and Wildlife Service as a candidate for addition to the List of Endangered and Threatened Species. In Illinois, the Endangered Species Protection Board is considering adding the cerulean warbler to its list of "threatened" animals.

Declines in cerulean warbler populations are generally thought to be caused by loss of critical habitat in breeding and wintering areas. Habitat requirements of this species have rarely been evaluated extensively, however. An ongoing Natural History Survey study of one of the largest remaining populations of cerulean warblers in Illinois may yield some insight into the breeding habitat needs and population dynamics of this species. Results of this study may help to explain why this warbler is declining, which may aid management programs for the species. Census data gathered during the study also will provide baseline numbers for comparison in future years.

Breeding populations are being studied in two areas, one in bottomland forest and one in upland. The bottomland study site is a 13-mile (21-kilometer) continuous stretch of Cave and Cedar creeks in Shawnee National Forest in Jackson County. The upland study site is a 3,250-acre (1,300-hectare) area in Trail of Tears State Forest in Union County.

Results from 1992 indicate that cerulean warblers in southern Illinois show very strong preferences for muddy, floodplain habitats with large trees; the population density of the bottomland study site was at least 20 times higher than that of the upland site. In the floodplain habitat, the 110 cerulean warbler territories located were generally in areas with scattered large trees such as sycamores, silver maples, and oaks, with a well-developed middle-canopy layer often consisting of box elder and elm.

The cerulean warbler.

The birds preferred the large trees, often huge sycamores, for singing perches. Many territories were located near edges, either natural (ponds, swamps) or artificial (agricultural fields, clearcuts). Unoccupied sections of the site were generally clearcuts or habitats dominated by young trees. Cerulean warblers also tended to avoid forests predominated by sweetgum or sycamore. If verified by subsequent analyses of vegetation data, these results will provide a strong indication that the suitable floodplain habitat was "saturated" with cerulean warblers, at least in 1992.

In the upland forests, most cerulean warblers were found in ravines and on ridge tops dominated by mature oaks

(more than 100 years old). Several territories were located in a selectively logged area where 20–30% of the trees had been removed, which indicates that cerulean warblers do not avoid forests with partially open canopies. Several additional upland territories were found next to agricultural edges and paved roads. Cerulean warblers nesting in both upland and bottomland forest therefore seem willing to live near edges as long as tall trees are present and the forest tract is fairly large.

Upland-nesting cerulean warblers show a strong tendency to aggregate within apparently suitable habitat. Although large sections of the upland site were unoccupied, 12 territories were located in a 250-acre (100-hectare) section with vegetation that appeared similar to that of the unoccupied sites (vegetation analysis has not yet been completed, however). These preliminary results therefore suggest that upland-nesting cerulean warblers prefer to settle near each other rather than spread out evenly over the entire habitat.

Recent theoretical models predict that territorial birds might benefit from settling near others of the same species, a phenomenon researcher Judy Stamps of the University of California has termed "conspecific attraction." If habitat is homogeneous, clustering may result from social advantages, such as increased mating success, better protection from predators and intruders, and enhanced habitat information. If habitat is heterogeneous and birds are found in similar patches, aggregations could result from local variations in food, shelter, nest sites, or vegetation structure. The study of aggregating behavior could have important consequences for management of species such as the cerulean warbler that may be declining because of landscape fragmentation.

Although upland-nesting cerulean warblers occur at much lower population densities, they may actually represent the bulk of the Illinois population because of the relative scarcity of preferred floodplain habitat. The population of upland-nesting birds might be limited by factors such as nest predation and brood parasitism rather than habitat availability. The floodplain-nesting warblers, however, may saturate the available habitat, which suggests that increasing the availability of muddy, floodplain forest habitat should increase cerulean warbler populations. The few remaining areas of extensive, mature floodplain forest in the state should be a top priority for conservation, land acquisition, and restoration.

Glendy C. Vanderah, Center for Biogeographic Information

Mosquito Studies in Chicago

Each summer since 1989, investigators with the Survey's Medical Entomology Program have studied mosquito populations in Chicago. Undertaken in collaboration with researchers from the Chicago Department of Health and Chicago State University, these studies have focused on mosquito species that transmit microbes causing disease in humans and that breed in containers such as used tires, cans, buckets, rain gutters, ornamental pools, untreated swimming pools, and tree holes. The four species currently under investigation are *Culex pipiens, Culex restuans, Aedes albopictus,* and *Aedes triseriatus.*

Culex pipiens (the northern house mosquito) and *Culex restuans* both transmit the virus that causes St. Louis encephalitis, a disease associated with inflammation of the brain. Both of these species lay their eggs on the surface of water in boat-shaped rafts. During her lifetime, a *Culex* female can lay up to three egg rafts, each of which can have more than 150 eggs.

To produce eggs, females of these species need to consume blood, which the mosquitoes usually get by feeding on birds. Because birds can also be a repository for the St. Louis encephalitis virus, the virus may be transmitted to the mosquitoes during feeding.

Culex restuans feeds only on birds and thus does not transmit viral infections directly to humans, though it can spread infections within the bird population. *Culex pipiens*, however, occasionally feeds on people. When this mosquito feeds first on an infected bird and then on a human, a case of St. Louis encephalitis can result.

Aedes triseriatus, the eastern tree hole mosquito, and *Aedes albopictus*, the Asian tiger mosquito, both lay their eggs just above the waterline in containers. The eggs hatch after they are flooded. Females can lay more than 200 eggs after each blood meal and can do this up to three times during their lifetime.

Aedes triseriatus is the primary carrier of the virus that causes La Crosse encephalitis, which is especially severe in children. The virus is picked up via a

Survey researchers have been studying populations of mosquitoes that breed in used tires, cans, and other containers in Chicago lots.

blood meal on an infected ground squirrel or chipmunk and then transmitted to a human during the following blood meal.

The Asian tiger mosquito can transmit both the La Crosse and St. Louis encephalitis viruses as well as 26 other viruses that cause diseases in people. Because of this mosquito's aggressive biting behavior, ability to carry a number of pathogens, and propensity to live in urban environments, its recent arrival into Illinois is of great public health concern.

Investigations in Chicago include studies on mosquito resistance to insecticides, biting and feeding behavior, population growth and movement, and the presence and location of mosquito-borne viruses. To carry out these studies, 20 sampling sites have been established throughout the city, in both residential and commercial areas as well as cemeteries. At each site *Culex* and *Aedes* species are collected as eggs, using containers (aluminum beverage cans and 5-gallon plastic buckets) that are painted black and that contain a mosquito attractant. The attractants used for *Culex* species, for example, are made of rabbit food pellets or grass.

During the summer of 1992 more than 2,100 *Culex* egg rafts were collected and identified to species. Peak egg-laying occurred during the week of July 12, when 450 egg rafts were collected. The number of egg rafts subsequently decreased dramatically, with minor fluctuations in number for the rest of the season.

More than 1,500 eggs of *Aedes* mosquito species were also collected during the summer of 1992. These eggs were collected in highest numbers during the first and second weeks of June. As with the *Culex* species, the number of eggs collected decreased and exhibited only minor fluctuations for the rest of the summer.

The Survey's Medical Entomology Program and the Chicago Department of Health plan to expand these investigations in 1993 to gain more information on mosquitoes and the pathogens they transmit in a large urban area. The goals are to use this information to predict the potential threat of human disease and to develop economically feasible and environmentally sound management procedures.

Robert J. Novak and Larry J. Szymczak (affiliate), Center for Economic Entomology, in cooperation with Roger N. Cieslik, Chicago Department of Health

Restoring Illinois' Wetlands

A wide array of natural wetland communities are found in Illinois, from Volo Bog in the northeast to the bald cypress swamps along the sluggish Cache River in the south. The more than 20 types of wetland communities that occur in Illinois are important in maintaining the quality of our water and containing floodwaters from storms. Wetlands also provide habitat for a great diversity of plants and animals; more than 40% of Illinois' endangered species depend on wetland habitats.

Although Illinois contained approximately 8.3 million acres of wetlands (23% of the land area) before settlement by Europeans, only 918,000 acres remain (about 2.5% of the land area); in addition, another 4,000 to 6,000 acres are still lost annually to urban development or conversion to agricultural use. Of the remaining wetlands, only 6,000 acres (less than 0.1% of the land area) are in high-quality, presettlement condition.

The federal government has historically provided incentives to drain wetlands. With increased knowledge and appreciation of the value of wetlands, however, government has recently attempted to slow the rate of wetland drainage and conversion. Section 404 of the federal Clean Water Act, for example, prohibits the placement of dredge or fill material into a jurisdictional wetland without a permit. (Nevertheless, only 5% of the 15,000 permit applications throughout the country are denied each year; the rest qualify under a general permit or are approved with modification to mitigate for the loss of wetland acreage and values.) At the state level, the Illinois Interagency Wetland Policy Act of 1989 requires state agencies to avoid wetland destruction when feasible and to mitigate or compensate for unavoidable wetland loss through means such as the creation of wetlands or the donation of funding for wetland research.

Wetland creation and restoration, relatively young but rapidly developing sciences, have become major focuses for mitigation efforts. Many wetland creation projects, however, have fallen short of equaling the myriad benefits that natural, high-quality wetlands provide. Despite high costs (ranging from $50,000 to

Survey staff monitoring permanent plots to assess vegetation change within a sedge meadow as part of a wetland creation project.

$350,000 per acre), many early wetland creation projects in Illinois failed because a key component of the wetland system, wetland hydrology, was not clearly understood or correctly implemented. Other failures were caused by inappropriate plant species chosen for the site, inappropriate substrates or soils, lack of goals for the success of the project and measures by which to gauge success, and an absence of (or poor execution of) a monitoring plan to determine whether the wetland was developing as designed.

Despite these difficulties, wetland creation and restoration are often the only options for mitigating the effects of unavoidable wetland losses, and these methods can be successful. The most important first step is to determine the type of wetland community to be established. Then, an appropriate site must be chosen. Restoration of former wetlands holds the greatest potential for success. For example, a wetland can be restored on a site that has drained hydric soils in an unaltered or minimally disturbed watershed by breaking tile drains or removing a levee to restore the natural hydrology. Locating the restoration site near existing wetland vegetation or a viable seedbank of remnant wetland species that can serve as a source for revegetating the new wetland will increase the likelihood of success.

Unfortunately, ideal sites for wetland restoration are rare, and some topographic or hydrologic changes are often required to create a wetland. Also, the intended wetland plant community often must be re-created by planting seeds or transplants of desired species. Knowledge of the growth requirements and of tolerances of individual species is necessary to promote establishment of a functioning system.

Another consideration in wetland creation is the spatial context in which a wetland is constructed. Wetlands are dynamic systems, tightly linked to the adjacent uplands in the watershed. The quality of the uplands will affect the quality and amount of water received by the wetland, in turn influencing the type and quality of the resulting wetland community. Because of this unbreakable link between upland and wetland habitats, the most successful wetland creation and restoration projects involve restoration of adjacent upland buffer zones to native plant communities such as prairies and forests.

More than 40% of Illinois' endangered species depend on wetland habitats.

When construction is complete and wetland hydrology is created or restored, scientists must monitor the site to determine whether project goals are being accomplished. The monitoring team can identify problems early in the development of the wetland so that necessary corrective measures can be taken. Typical monitoring programs continue for five years and involve recording water levels and water chemistry information throughout the year, assessing vegetation communities through quantitative sampling, and assessing wildlife usage of the area.

Wetland scientists at the Natural History Survey have recently become involved with many aspects of wetland mitigation in cooperation with the Illinois Departments of Transportation and Conservation. The Survey group is presently involved in monitoring 10 created wetlands under one project, with nine other projects at earlier stages of planning. A database is being compiled to evaluate which techniques are most effective, and a practical guide for wetland creation, restoration, and enhancement is being written by the group for the state of Illinois.

Scott Simon, Alicia Nugteren, Marilyn Morris, Center for Biogeographic Information

New Field Guide to Mussels

The Natural History Survey has just published a first-of-its-kind field guide to freshwater mussels of the Midwest. Authored by Survey investigators Kevin S. Cummings and Christine A. Mayer, this 208-page, hardcover book will help amateurs and professionals alike in identifying species, many of which look remarkably similar. A color photograph of the shell of each species enables quick identification.

The front section of the book includes information on the biology, economic importance, and conservation of freshwater mussels, among the most endangered animals in North America. Surveys over the past few decades have documented significant declines in mussel populations due to overharvesting, competition from exotic species such as the zebra mussel, water pollution, and other factors.

The bulk of the book consists of species accounts for each of about 75 native mussels. The text of each account includes a description of key characteristics and the habitat in which the mussel is normally found; each account also contains a color photograph of the shell and a range map showing the geographic distribution of the species.

The new book is the fifth in the Survey's series of field manuals. The previous four volumes, which covered wildflowers, snails, shrubs, and mammals, were published between 1936 and 1957. The issuance of Manual 5 thus reactivates a long-dormant but important Survey publication series.

Field Guide to Freshwater Mussels of the Midwest can be purchased from the Survey for $15 by writing to Distribution Center, Illinois Natural History Survey, 607 East Peabody Dr., Champaign, Illinois 61820 (phone: 217-333-6880).

Editor's Note

The educational features titled "Species Spotlight" and "The Naturalist's Apprentice," which normally appear on pages 6 and 7, will return in the May/June issue.

Living on the Edge

Undisturbed natural habitat has become scarce in Illinois. In fact, only about 11% of the state remains in its original, presettlement vegetation type. This remaining habitat is not only reduced in area but also invaded by roads, agricultural fields, and homes so that it often becomes divided into smaller tracts, called fragments.

As habitat fragmentation proceeds, natural areas are often affected in subtle ways. For example, when large areas of forest are broken up, the amount of edge habitat increases. Forest edges can differ from forest interiors in temperature, humidity, and amount of sunlight that reaches the understory. These factors can affect the type and abundance of vegetation, as well as the animals that live there. Forest edges can provide needed cover to animals while allowing them access to rich food resources such as agricultural products. Thus, in some cases, forest edges can yield higher densities of animals than forest interiors.

With increased fragmentation, the ratio of edge to interior habitat increases. In other words, there is more forest edge per unit area of forest interior. This also means that interior sites are generally closer to edges and less isolated from edge effects. Species that do not normally occur in deep forests may have greater access to forest interiors. Increased abundances of animals along forest edges may also result in higher than usual numbers in forest interiors due to dispersal and colonization. This may not always be desirable, as when increased exposure to nest parasites (such as cowbirds) or potential nest predators (such as raccoons, opossums, and chipmunks) negatively affects the reproductive success of forest-dwelling songbirds.

In a study conducted last summer in southern Illinois, species composition and abundances of furbearers and small mammals (mice, chipmunks, shrews, etc.) were compared between 11 upland forest interior sites and 11 edge sites where the forest abutted various kinds of agricultural fields. Furbearers were detected by monitoring tracking stations where animals attracted to baits left footprints on soot-covered aluminum plates. Small mammals were censused by live trapping. Nest predation on forest songbirds was also examined at six each of these interior and edge sites in an independent study by Miguel Marini, a graduate student at the Natural History Survey and the University of Illinois.

Forest edges provide cover to animals while allowing them access to crops.

Although furbearer activity and abundance was slightly higher at the edge sites, the difference between edge and interior sites was not statistically meaningful, and both types of habitat showed a wide range of variation. Raccoons and opossums were abundant throughout the area and accounted for 93% of the track records; coyote and fox records were less common but occurred more often along edges. Similarly, the number of small mammals varied greatly among sites, and there was no consistent difference between forest edges and interiors. There was only a very weak relationship between mammal numbers and predation of bird nests.

Does this mean that there are no edge effects on mammals in southern Illinois forests? An equally tenable hypothesis is that there is no real forest "interior" for mammals in this region. Because of the human activity in this area, the best interior sites in this study were no more than about 1,000 yards from an edge of some kind. It may be that even many heavily forested areas do not provide an environment that is totally free from the consequences of human activity. Future directions for this research include studies of animal movements and population dynamics in fragmented landscapes and comparisons with more isolated, true deep forest interiors.

Raccoons were abundant at all sites.

This research was funded by the USDA Forest Service and conducted with the cooperation of managers of the Shawnee National Forest, Trail of Tears State Park, and many private landowners.

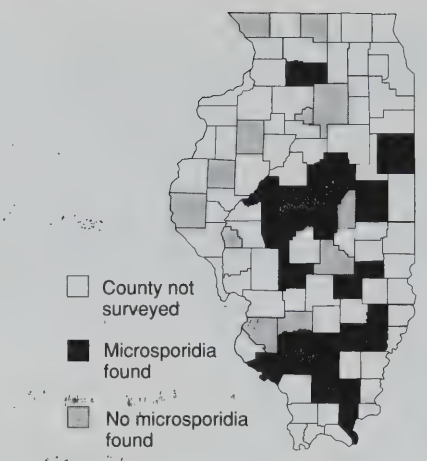
Ed Heske, Center for Wildlife Ecology

Discovery of a New Pathogen of Alfalfa Weevils

The alfalfa weevil is the most destructive pest of alfalfa in Illinois. Although pesticides can curb weevil numbers, they are costly and add to groundwater pollution. To assess natural biological control in alfalfa weevils, Natural History Survey researchers have conducted three statewide surveys for weevil pathogens since 1966.

Several pathogens that cause disease in field populations of alfalfa weevils have been previously reported, including fungi and three species of microsporidia (single-cell parasites). Two of the microsporidia were found in laboratory colonies in New Jersey and Utah and have never been reported from field collections. The third was found only in a few alfalfa weevils in Illinois. None of these microsporidia appears to cause epizootics in adult weevils.

A fourth, and distinctly different, microsporidium was discovered during a 1990 survey of alfalfa weevils in Illinois. The pathogen was found in weevil



The new pathogen was found in 24 counties.

populations throughout the state, and it has also been found in a laboratory colony established from field-collected weevils at Ohio State University and in field samples from Louisiana, Maryland, and Missouri. The percentage of weevils infected with the pathogen ranged from 1 to 50% among the Illinois counties in which it was detected.

The microsporidium develops in various tissues in the weevil but appears primarily to attack the fat body, an organ critical to the metabolic function of insects. Spores develop from rapidly reproducing vegetative forms in the host cells. The minute spores are released into the weevil's digestive system and are infective when eaten by other weevils. Experiments have shown that healthy weevil larvae can become infected by eating spore-infested plant material, and infection can also be passed from females to their offspring through the egg.

Ongoing experiments are assessing the effects of the pathogen on alfalfa weevils. The microsporidium has not been previously described as a species, and microscopy studies are being conducted to describe its life cycle and characteristics. These studies and a determination of the pathogen's host range are necessary steps in evaluating this organism as a naturally occurring biological control agent.

Leellen F. Solter, Stephen J. Roberts, Joseph V. Maddox, and Edward J. Armbrust, Center for Economic Entomology

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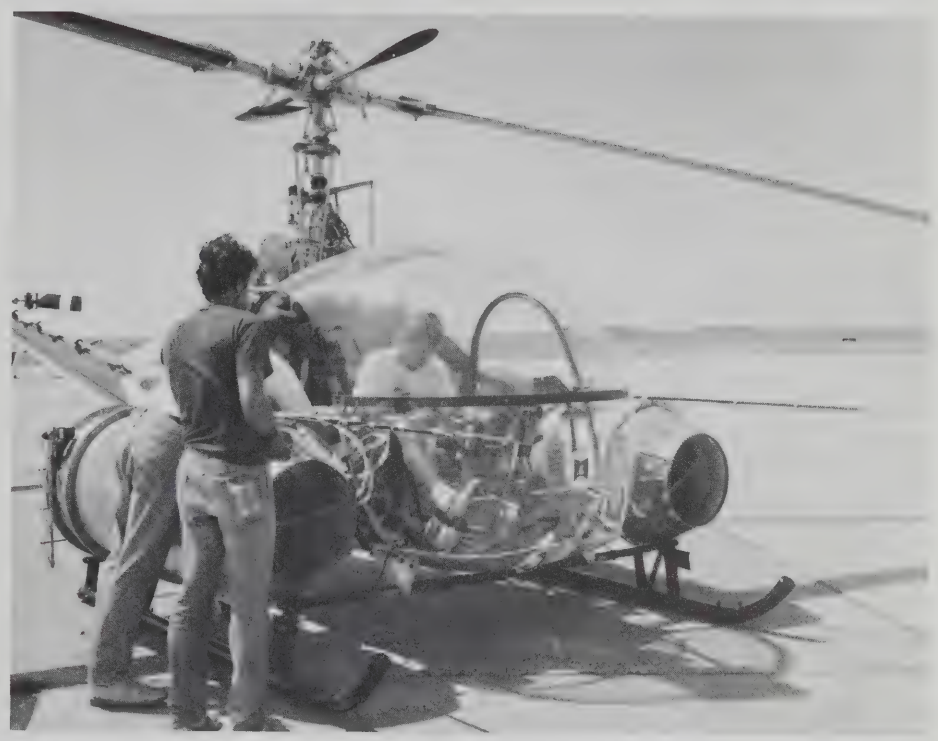
Predicting Movements of Airborne Organisms

Light-weight organisms, such as aphids, can be lifted into the atmosphere and transported hundreds of miles by winds. Many of these airborne organisms are important because they can damage crops or carry viruses that cause diseases among plants, or even among people. To better predict and manage problems associated with airborne agricultural pests, Natural History Survey researchers have teamed up with other scientists to study the process of aerial transport.

Although many insect pests in Illinois are killed each winter by the harsh cold, new members of these species may be carried each spring to Illinois on air currents from their overwintering habitats in the Gulf Coast states and Mexico. During the growing season they disperse widely throughout North America, and in the autumn some of their descendants move to the south, where they spend the winter. These traveling pests can lead farmers to use (and sometimes overuse or misuse) potent pesticides, and in so doing increase the cost and impede the flow of agricultural commodities.

Over the past decade, a team of entomologists, agronomists, plant virologists, meteorologists, engineers, and geographers at the Natural History Survey, the Illinois State Water Survey, and the University of Illinois have been conducting research on the aerial transport of organisms, especially aphids. The team was first brought together to work on the Pests and Weather Project, funded between 1982 and 1984 by the Illinois Department of Energy and Natural Resources. This project allowed researchers to develop a framework for following migrating aphids from their source areas in southern states into crops in Illinois. This involved genetic differentiation of aphid populations in southern states, flight energy utilization studies, radar observations of migrating insects, atmospheric trajectory modeling, and aerial sampling of aphids. The Pests and Weather Project established the foundation for a continuing series of studies supported by grants from the U.S. Department of Agriculture.



Researchers have used helicopters to collect airborne insects. Insect collection chambers are mounted on the sides of the aircraft above the skids.

Because detailed knowledge of the altitude of insect flight within the lower atmosphere (below 5,000 feet altitude) is required for accurate atmospheric trajectory analyses, the meteorological factors that govern the vertical zonation of migrating aphids emerged as an important research focus. The role of aphids in the epidemiology of important diseases caused by plant viruses in soybeans, corn, wheat, and oats has also been an ongoing research thrust.

INSIDE

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Current research is evaluating the roles of biological and environmental factors that influence the ascent of aphids into the atmosphere. The research effort is divided into two parts. First, a set of greenhouse experiments will study aphid flight trajectories under a variety of controlled biological and environmental conditions. Second, relationships between biological/environmental factors and aphid flight trajectories, developed during the greenhouse experiments, will be evaluated in an agricultural field setting.

These studies concerning the effects of biological and meteorological factors on long-distance aerial movement of aphids and other weakly flying insects have important implications for crop protection. If the forces that move air in the lower atmosphere also govern the vertical movement of aphids as they ascend into the atmosphere, then most aphids that take flight from agricultural fields in the Midwest land many miles downwind. Aphids taking off during warm sunny afternoons in the growing season may be lifted thousands of feet into the atmosphere by thermal convection, and upward air motions are often strong enough to keep the aphids airborne until after dark. Because aphids do not appear to land at night, it is not until after dawn that atmospheric conditions and the actions of the aphids are conducive to flight termination, by which time the aphids may have been transported hundreds of miles.

To develop strategies for adequately protecting crops and people, researchers need to gather timely and accurate data on the types, numbers, and arrival dates of important aerially transported species. In agriculture, this is especially important because the ability to predict the movement of organisms that are resistant to pesticides into areas that are otherwise free of them is essential for developing successful pest control strategies. If long-distance aerial movement of organisms occurs as frequently as hypothesized, then greater emphasis must be placed on developing and implementing large-scale, area-wide crop protection strategies.

Scott A. Isard (affiliate) and Michael E. Irwin, Center for Economic Entomology

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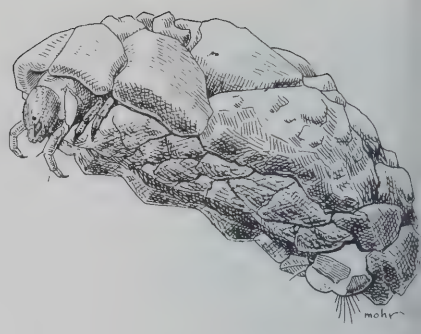
Stream Community Dynamics

Ecologists seldom have the opportunity to observe how individual species affect the organization and integrity of the communities in which the species live. In an era of markedly increased extirpation of species, there is a pressing need to understand how species influence the structure of communities and, in particular, whether the removal of one or more species will make a community more vulnerable to human or natural disturbances. Experiments, though valuable, are usually not as effective as we would like in addressing these issues because they generally examine only short-term changes in relatively small areas.

Researchers have recently been provided a unique opportunity for seeing over a long time and over a broad geographic area how a single dominant species, the caddisfly *Glossosoma nigrior*, affects the organization of some stream communities. *Glossosoma* larvae are small (less than 1 centimeter long), herbivorous insects that eat algae growing on the stream bottom in fast-flowing water. Previous research has shown that these larvae strongly affect other members of the benthic invertebrate community in small coldwater streams in the Midwest and Rocky Mountains. By keeping algae in low supply, the larvae reduce the abundance or limit the distribution of other insects that eat algae. The larvae appear relatively immune to predation because they inhabit a case



Glossosoma larvae inhabit a case constructed from sand grains.

constructed from sand grains, which may deter many predators.

Beginning in the mid-1980s, *Glossosoma* populations in many streams have become infected with a previously undescribed species of the microsporidian parasite *Cougourdella*. In all known cases in which the parasite has become established in a stream with *Glossosoma*, the *Glossosoma* population has precipitously declined from typical population densities of 2,000–5,000 larvae per square meter to fewer than 5 larvae per square meter. In most cases, the *Glossosoma* populations have been held at very low levels by the parasite. Although the parasite is spreading, many streams remain uninfected.

Dramatic changes have been observed in streams in which *Glossosoma* populations have been affected by *Cougourdella*. Algal populations have generally increased at least twofold, and changes in the species composition of the algae have been observed. The most striking changes have occurred among the invertebrates that, like *Glossosoma*, consume algae growing on rocks. In all streams in which *Glossosoma* has been affected, several species that were previously extremely rare or absent have become established and now maintain large populations. Most of these species are also caddisflies. In particular, populations of the limnephilid caddisfly *Goera stylata* have become established in all streams in which *Glossosoma* populations have been devastated. *Goera* was previously unknown from these streams and, in general, was considered to be quite rare.

These findings illustrate the value of long-term studies conducted over relatively broad regions and demonstrate the powerful influence of *Glossosoma* on the organization of coldwater stream communities. It is still unclear whether *Glossosoma*'s influence extends to other trophic levels (e.g., fish) in these systems, as suggested by theoretical arguments, and whether the communities will return to their original configuration if *Glossosoma* populations recover. It is hoped that continued research will provide the answers to these and numerous other questions about these systems.
Steve Kohler, Center for Aquatic Ecology

Migration of Canada Geese

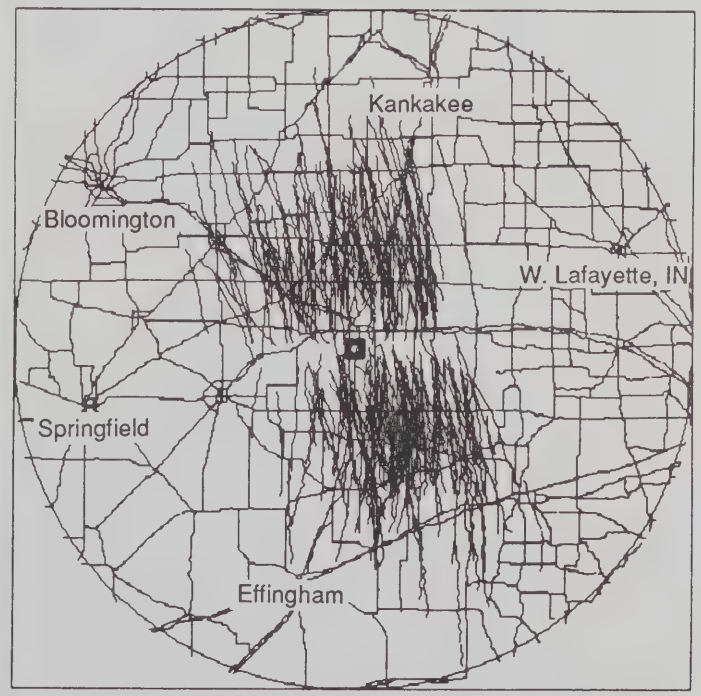
During the winter, southern Illinois is home to nearly a million Canada geese (*Branta canadensis*) that belong to what is called the Mississippi Valley population. These geese breed during the spring near Hudson's Bay in Canada, take advantage of a very productive though short summer growing season to raise their young, and then head south for the winter. Usually, most of them stop over in the general vicinity of Horicon National Wildlife Refuge in Wisconsin until ice and severe weather drive them farther south, mainly to lakes in southern and western Illinois. (Another, larger race of Canada geese breeds in Illinois and is often seen on lakes and making local flights.)

When geese of the Mississippi Valley population decide the time is right to come to Illinois, the decision seems to be nearly unanimous: up to 700,000 geese leave Wisconsin within one or two days and fly nonstop across Illinois. It is a spectacular sight; one person with binoculars can see many thousands of geese migrate by in a single day, flying in vees or echelons in flocks of 40 or 50, up to the maximum size of 1,640 counted by Natural History Survey scientists.

In 1987–1989 Illinois was fortunate to have a large radar facility that was used to observe the migration of the Mississippi Valley population. The illustration below shows part of the migration during the afternoon of December 28, 1988. The radar, located just south of Champaign, recorded the position of the geese about every minute, and an artificial intelligence computer program connected the recorded positions and reconstructed the paths of the flocks. The result is a perspective on Illinois wildlife that humans cannot achieve on their own.

Each line on the plot represents a flock of geese tracked for 30 minutes or more by radar; the interruptions in the paths result from the radar's inability to follow the geese as they fly broadside. Flying at about 600 to 1,000 feet, the geese appear over the horizon in the north and northwest and fly straight for the most part, although some flocks can be seen to make course corrections. (The tiny squiggles result mostly from the radar detecting the east versus the west ends of the flocks.)

The radar records show that each year the geese are carried to the east by strong northwest winds, and they are, in fact, observed in the Wabash Valley in Indiana before they make a short "connecting flight" back to Illinois the next day. If one works backward along the paths, the main pulse of geese is found to have left within 3° of Horicon, Wisconsin, shortly after dawn. Radar records also indicate that the migration is massive. Anywhere along a line through such a migration, about 100 tons of geese per mile pass by during the 11-hour period.



Canada geese were tracked through Illinois using radar. Each line on the plot represents a flock of geese tracked at least 30 minutes.

Natural History Survey studies of migrating geese have been conducted in cooperation with the Illinois State Water Survey and with the support of the U.S. Fish and Wildlife Service and the U.S. Air Force, agencies interested in reducing the hazard birds pose for aircraft.
Ron Larkin, Center for Wildlife Ecology

Environmental Changes in the Kaskaskia River Basin

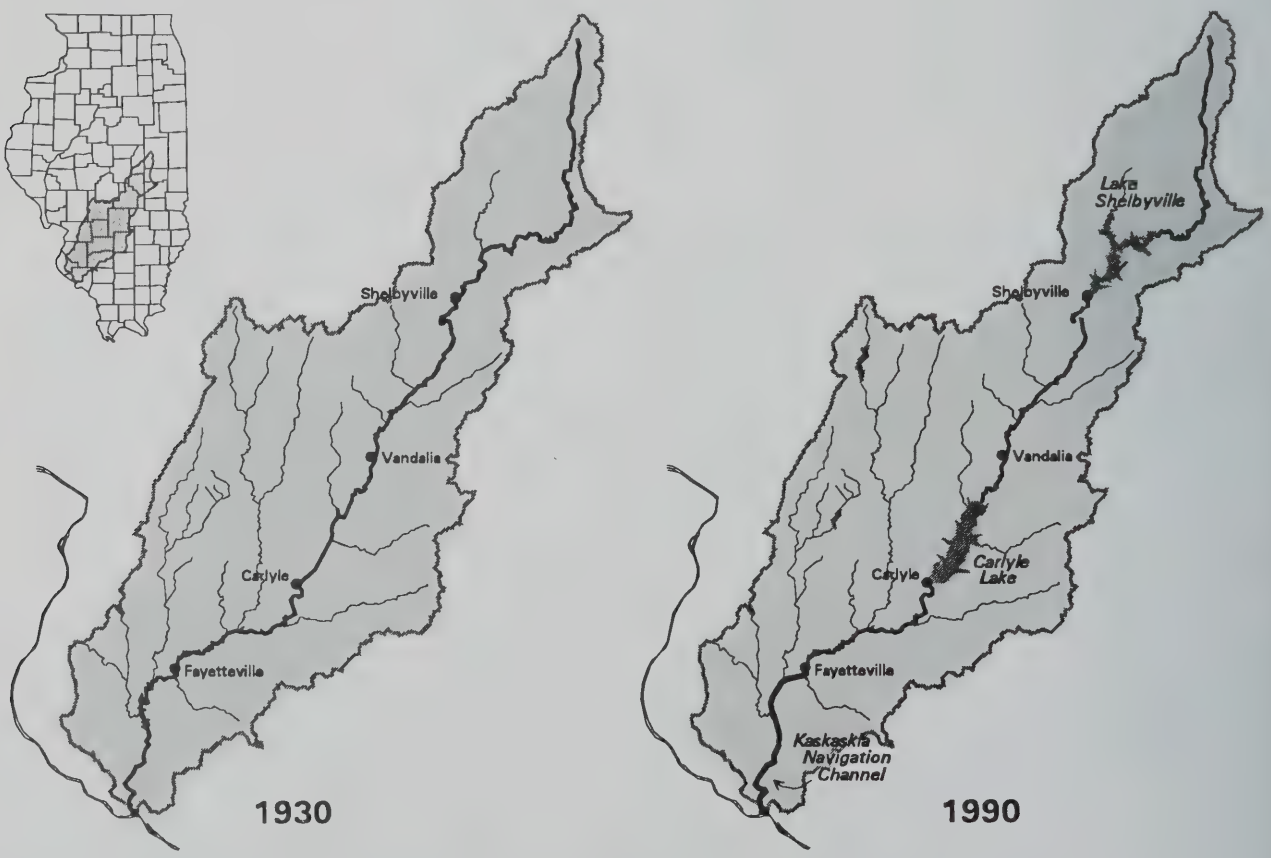
The Kaskaskia River has been channelized, impounded, and polluted since the first people of European descent settled in the basin and proceeded to modify the river's drainage, water quality, and aquatic communities. The tallgrass prairie of the upper basin has been drained, and most of the forest has been removed from the rest of the basin as agriculture has become the major industry.

After the Civil War, when approximately 200,000 people lived in the Kaskaskia Valley, the economic interests of the settlers had an enormous impact on the Kaskaskia Basin, the river, and its major tributaries. The Illinois Farm Drainage Act of 1879 enabled farmers to drain large areas in the basin. Channel clearing and straightening, as well as ditching of poorly drained areas, lowered the water table and hastened water runoff. As a consequence, flood peaks became higher, and low flows became lower. Stream habitats were destroyed in areas that were dredged and drastically modified elsewhere by changes in the water regime.

Dredging and draining also eliminated many floodplain pools and wetlands. In Moultrie County, for example, the number of acres in natural wetlands decreased from about 89,000 before settlement to about 1,600 in recent years. Floodplain pools and wetlands are critical parts of the basin's aquatic ecosystem because they process nutrients, provide food and spawning areas for river fishes, contribute young fish back to the river, and provide angling opportunities. Other pools and wetlands, though not eliminated, have been biologically degraded through isolation from the flushing floods of the river.

The next major modification in the basin was the impoundment of the river at Carlyle and Shelbyville. The dam at Carlyle was virtually complete in 1965 and eventually impounded almost 24,600 acres of water. At Shelbyville, the dam inundated 11,100 acres of timber and bottomland field.

Another modification was channelizing the river below Fayetteville so coal could be transported from the New Athens area to St. Louis by barge instead of by railroad. This project, completed around 1973, shortened the



The Kaskaskia River Basin in 1930 and 1990. Note the three main changes in the basin: the creation of Lake Shelbyville and Carlyle Lake and the channelization of the river below Fayetteville. Maps created by Kate Hunter.

iver between its mouth and Fayetteville rom 52 to 36 miles; meanders were liminated, much of the channel was xcavated, the banks were piled with poil, and the flow and water level were rought under control by building a lock nd dam near the river's mouth.

The biological effects of the Kaskaskia River modifications have been ocumented by Natural History Survey esearchers, who have been studying hanges in the plant and animal commu- ities of the basin's aquatic habitats since efore the turn of the century. A recent urvey of mussels, for example, suggests hat 15 species previously found in the asin may have been extirpated from the rea; it also found a 76% reduction in bundance of mussels. Construction of he two reservoirs, channelization of the ower river, and the building of the avigation lock and dam just above the iver's mouth damaged or destroyed nany high-quality mussel habitats.

Natural History Survey researchers ave also studied the fish populations of he Kaskaskia River and its tributaries. hese waters have historically supported iverse communities of fishes, primarily innows, sunfish, catfish, suckers, and arters. A total of 110 native and 14 non- ative fishes have been taken. This xceptionally large number of species is robably due to the large number of nusual habitats, such as marshes, sand- ravel riffles, deep pools, brushy sloughs, nd bottomland waters.

The degradation of these unique abitats through drainage and dredging rojects, pollution, construction of dams nd impoundments, and increased edimentation has led to declines in bundance of some species, and some pecies are in danger of being eliminated rom the basin. One fish species is a andidate for federal endangered status, hree are listed as state-endangered, and wo are considered state-threatened. wenty are rare or possibly extirpated rom the basin. Kaskaskia River fish opulations are at risk of further decline rom the removal of river bottomland imber, increases in levels of pollutants, and additional modifications to the river or its tributaries.

In sum, development projects have eliminated or drastically modified aquatic habitats in the Kaskaskia Basin. Some of the effects of development have been immediate; others have been subtle and chronic. The impact on aquatic habitats and aquatic communities must be understood to minimize the bad effects and optimize the potentials for good. *R. Weldon Larimore, Center for Aquatic Ecology*

Seep Communities

The importance of wetland ecosystems has been a popular topic in recent years, capturing the attention of biologists, government regulators, and the general public alike. Destruction of wetlands, mainly caused by the expansion of agriculture and urban development, has generated a compelling interest in preserving the remaining natural wetlands in Illinois and, in some cases, in creating wetlands to compensate for the vast acreage lost. Although many aspects of wetlands and some wetland types have been extensively studied, biological and hydrological information about many types of wetlands remains scant. Gathering more information is essential to understanding the effects of water quality on wetland ecosystems.

One type of wetland found in Illinois is called a seep, which is formed where groundwater flows to the surface through porous material such as gravel or sand. Seeps are similar to springs except that the water generally flows diffusely from the ground rather than from a definite spot or orifice. The water of most seeps is somewhat calcareous, that is, rich in calcium carbonates. Seeps are usually located in stream valleys and along the lower slopes of terraces and ravines; they are often found close to other wetland communities.

In the spring of 1991, following a suggestion from Department of Conservation biologist Bob Szafoni, Natural History Survey botanists began a three-year study of 12 seep communities in Vermilion County (east-central Illinois). The study focuses on seeps located in the watersheds of the Middle Fork of the Vermilion and the Vermilion River. Four of the seeps are Illinois nature preserves, and one is a National Natural Heritage Landmark.

Skunk cabbage is found in places that are moist throughout the year.

Most of these sites had never been inventoried floristically; at the sites for which species lists were previously compiled, the current study has been the most concentrated effort to inventory the complete plant community. The goals of the project have been to locate and map all of the known seep communities in these watersheds; to gain an understanding of the floristic composition of these rare wetland communities, including an inventory of rare or threatened and endangered plants; and to evaluate the hydrologic and chemical component that created and that maintains these communities.

The seep communities occupy a wide variety of positions within the landscape. Four of the seeps primarily form wetlands on hillsides and drain into a ravine, streams, or a pond. The remainder of the seeps emerge near the base of a slope and blend into larger marshes or forested

(Continued on back page)

Double-crested Cormorant

During an enjoyable late spring day a glance skyward reveals a familiar V shape. Although migrating geese immediately come to mind, an ornithologist friend says no, these are not Canada geese but a flock of double-crested cormorants. Like geese, these birds migrate in large,V-shaped flocks, but unlike Canada geese, they are silent.

Double-crested cormorants are goose-sized, slender, and dark; they have a long neck, a thin hooked bill, and a yellowish-orange throat pouch. Webs connecting the four toes aid in swimming.

After alighting on a lake, cormorants generally float on the surface and look around for a while before diving for their food, usually fish. Once a fish is caught, the cormorant tosses it about until it lands headfirst in the bird's throat, preventing the fins from tearing the gullet on the way down. After catching its fill, the cormorant will find a suitable perch, shake its body vigorously, wag its tail feathers from side to side, and wave its wings because its feathers are not completely waterproof. To further dry itself, the bird will face the wind and extend both wings, holding them stationary or slowly waving them back and forth.

Early ornithologists believed that all double-crested cormorants seen in Illinois were migrants. In the early 1900s, a few nesting colonies were found in the state,

There are at least six active nesting colonies of double-crested cormorants in Illinois.

but by 1960 only one colony with seven nests remained. Because the double-crested cormorant was thought to be dying out, it was added to the Illinois endangered species list. In 1976 the Department of Conservation began to erect artifical nesting platforms, and the sole remaining colony began to slowly recover. Now there are six known active nesting colonies in Illinois.

Nests are generally found near water, often in a dead tree. Nest trees, in fact, may be dead not because the birds seek out dead trees but because they may be killed by the cormorants' gauno. The gauno contains a high concentration of phosphoric acid, which kills vegetation.

Although the male cormorant selects the nest site, the female builds the nest—a scruffy collection of sticks, small branches, and weeds resembling a small beaver lodge in a tree. The female has one brood of 3-5 eggs per year that hatch in about 25 days. The hatchlings are naked, blind, and helpless and can die rather quickly from exposure to heat or cold; within three weeks, however, the birds are covered with a jet black down. After the young are fully feathered, they take to the water; a young cormorant can swim and fish before it can fly. Nearly three years pass before the young breed.

During the 1940s and early 1950s, autumn brought thousands of double-crested cormorants to fish in the large bottomland lakes of the Illinois River Valley. In 1950, for example, Natural History Survey researchers counted over 15,000 cormorants fishing in these quiet lakes. By the end of the decade, though, the number had dwindled to less than 500, and by the mid 1960s only 22 cormorants were observed during an inventory. With the widespread destruction of wetlands in the valley, the cormorants apparently no longer find the area such an appealing place to stop and fish. Also, people who catch fish have sometimes made these birds less than welcome because of the perception that cormorants eat huge numbers of fish.

Although the great migrating passages of these birds have disappeared, a stray V of "nonhonking geese" passing overhead on a warm spring afternoon might just turn out to be an elusive flock of double-crested cormorants.

Teacher's Guide to "The Naturalist's Apprentice" (facing page)

OBJECTIVE to learn the relationship between the shape and function of bird beaks and feet

SKILLS observation, deduction

MATERIALS copies of "The Naturalist's Apprentice"

COMMENTS This activity encourages students to discover how organisms, in this case birds, are adapted to their environment. This installment of "The Naturalist's Apprentice" may be conducted as suggested, or in other ways: 1. Create a bulletin board display on shape and function, with drawings of bird beaks and feet forming a central core, surrounded by statements about the specific functions of the beaks and feet. 2. Copy the handout onto a transparency and present the material with an overhead projector. Students can discuss the possible functions of the various beaks and feet or write their answers for later discussion.

PROCEDURE Distribute copies of "The Naturalist's Apprentice" and ask students to complete the worksheet. *Correct answers: tearing flesh – D (bald eagle), crushing seeds – A (cardinal), swimming and diving – F (cormorant), wading – K (heron), grabbing prey – G (hawk), dabbling for food under water – B (mallard), catching insects – C (thrasher), perching – E (sparrow), swimming on surface – H (shoveler), nectar feeding – I (hummingbird), catching fish – J (cormorant).*

EVALUATION The completed worksheets can serve as the evaluation for this activity. Student work related to the alternative procedures suggested in the comments section may also be evaluated.

Beaks and Feet: What Are They Used For?

Match each beak or foot with its function. Suggest a bird that might have the type of beak or foot shown in the drawing.

___ tearing flesh _____

___ crushing seeds _____

___ swimming and diving _____

___ wading _____

___ grabbing prey _____

___ dabbling for food under water _____

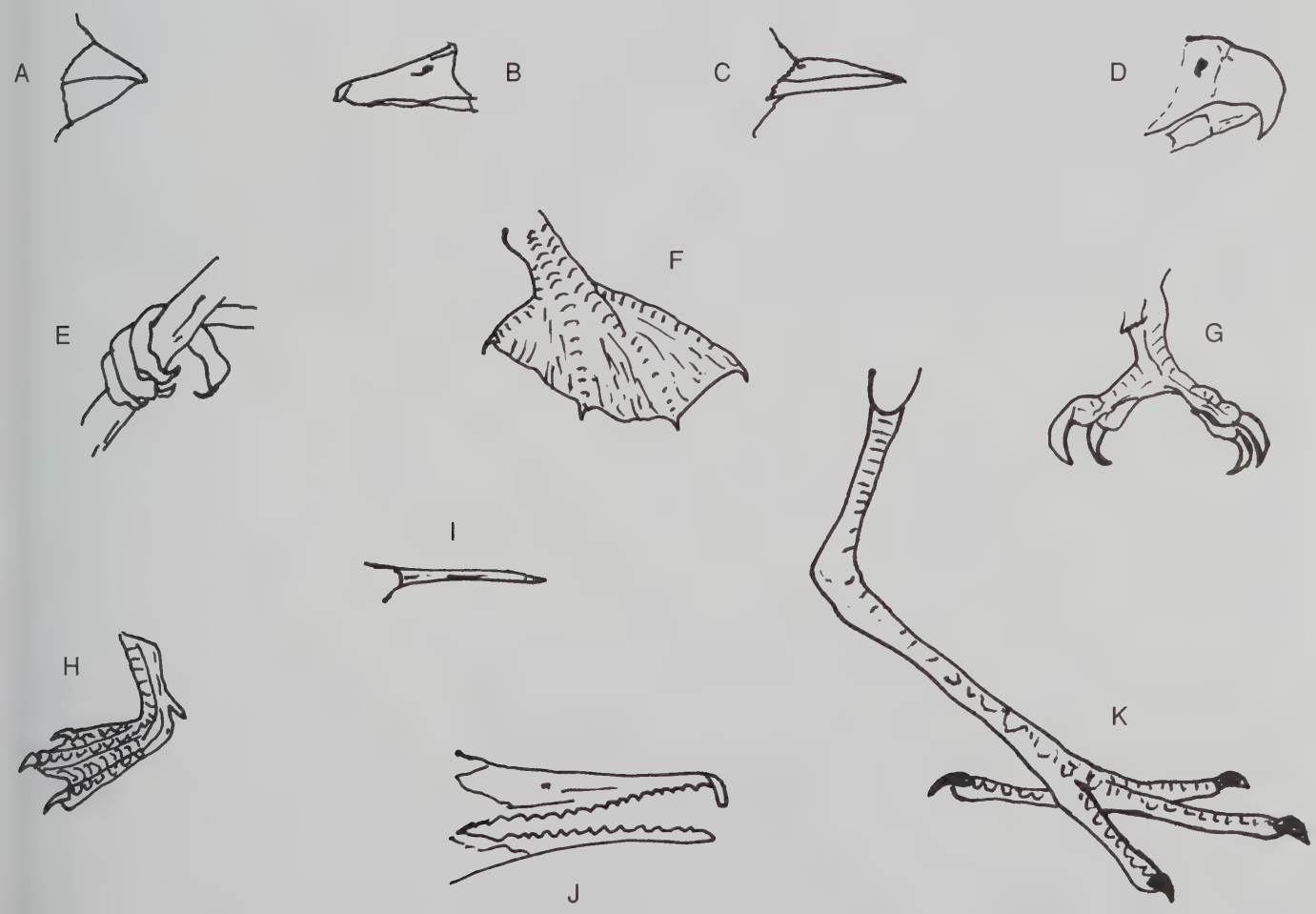
___ catching insects _____

___ perching _____

___ swimming on surface _____

___ nectar feeding _____

___ catching fish _____



(continued from page 5)
wetlands downslope. Soil types also differ among the seeps. The hillside seeps tend to emerge from gravelly substrate, whereas the soils in the seeps that emerge lower on the slope are usually very organic.

In addition to being mineralized, the groundwater that seeps to the surface is generally cooler than surface water. These characteristics create unique conditions for the development of diverse and uncommon plant communities. A seep that emerges at Windfall Prairie, for example, supports over 115 plant species, including a grass listed as threatened in Illinois, though the site is smaller than a quarter of an acre. Often, plants typically known from more northerly locations are found within Illinois seeps, isolated from their normal ranges by many miles. These species are relicts from periods thousands of years ago when the climate in this region was colder; they survive now in Illinois only in the cooler seep environment. Many of these northerly plants have been found in the 12 seeps surveyed and include grass-of-Parnassus, black ash, swamp saxifrage, marsh marigold, skunk cabbage, and several sedges. The native thistle, *Cirsium muticum*, has been found at five sites and is of special interest because it is the only known host plant for the swamp metalmark, a rare butterfly. This butterfly has been observed within the past 20 years at only three locations in the state, including one of the study sites, and is on a state watch list for rare species.

Because seeps are fed primarily by groundwater, "cleaned" as it flows underground, they have not been affected by water pollution as much as wetlands receiving water from surface sources. Seeps have also been somewhat protected from human activities because they are typically located on fairly inaccessible slopes. Thus, many seeps have remained relatively unchanged from before Europeans settlers arrived and altered the land. Probably the worst threats have arisen from damage to the fragile soils and in turn to the plant and animal communities by livestock grazing.

In 1993, the study is expanding to include the analysis of soils and groundwater at each seep. For example, water samples from each locale will be analyzed for pH, temperature, calcium carbonate concentrations, and other characteristics. These samples will be compared among seeps and with samples from other wetland types. Additional studies will include vegetation sampling to determine which plants dominate each seep community and how plant composition correlates with canopy closure, that is, the amount of sunlight reaching the ground. A final outcome of the entire study will be the formulation of recommendations for managing these important components of our natural heritage and for further work in preservation and creation of wetland communities.

Marilyn Morris and Scott Simon, Center for Wildlife Ecology, and Loy R. Phillippe, Center for Biodiversity

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REPORTS

July/August 1993 No. 322

Plight of Forest Birds in Northwestern Illinois

As roads, homes, and agricultural fields invade a forested area, the forest becomes divided into small, isolated tracts. This fragmentation of the habitat makes the nests of forest birds more vulnerable to harm from species that live outside of or at the edges of the forest. Consequent detriments to nesting success, such as increased nest depredation, are perhaps more evident in Illinois than anywhere else in North America.

Natural History Survey studies in recent years in central and southern Illinois found unusually low nesting success for many forest birds living in fragmented habitats. Up to 90% of the nests of some forest birds were parasitized by brown-headed cowbirds, which lay their eggs in the nests of other (host) species. Because the host birds usually raise cowbird young instead of their own, high parasitism levels have severe negative effects on population dynamics. Nest predators such as raccoons, snakes, and blue jays were also abundant; nest depredation levels were twice as high as those in typical unfragmented forests and reached 90% for some species.

Neotropical migrants, which breed in Illinois and winter in Central and South America, generally had the lowest reproductive success because their simple, open-cup nests are vulnerable to both cowbird parasitism and nest depredation. Productivity of some Neotropical migrants, such as the wood thrush and hooded warbler, was probably too low to compensate for adult mortality. If these findings are typical of statewide nesting success, then populations of many forest birds of Illinois are likely being maintained only by immigration from outside the state.

A field assistant looks for a ground nest, which may be vulnerable to depredation by raccoons.

In 1992, studies of nesting success were expanded to northwestern Illinois. The first year of this three-year study focused on the largest available forest tracts, which included Hanover Bluff, Mississippi Palisades State Park, and Ward's Grove. Rhetta Jack, a graduate student at the University of Illinois, studied the nesting success of the wood thrush for her master's thesis.

Forest bird communities of northwestern Illinois contained a mixture of southern species near the northern edges of their ranges (e.g., hooded warbler) and northern species at the southern edges of their distributions (e.g., chestnut-sided warbler). The few ravines that were not being used for recreation or agriculture had particularly rich bird communities similar to those in Shawnee National Forest. Significant populations of the

INSIDE

♦

veery (a threatened species in Illinois) and the cerulean warbler were located, as well as large populations of ovenbirds.

Unfortunately, forest songbird nesting success in northwestern Illinois in 1992 was generally no better than it was elsewhere in the state. More than 80% of wood thrush nests were parasitized by cowbirds, and each parasitized nest usually contained at least two or three cowbird eggs. Veeries, ovenbirds, indigo buntings, Louisiana waterthrushes, and scarlet tanagers also suffered from high levels of nest parasitism. Parasitism levels were particularly high near recreational areas such as campgrounds that provide feeding opportunities for cowbirds; they were high even in the interior of the largest forest tracts.

Depredation of ground nests was much greater in northwestern Illinois than it was in central or southern Illinois. Ground nesters such as the ovenbird, Louisiana waterthrush, and Kentucky warbler suffered predation levels of 60–99%, compared with levels about half that high in southern Illinois. Raccoons, which regularly depredate ground nests, appear to be much more abundant in northwestern than in southern Illinois, and this may account for the observed difference.

Canopy nesters also appeared to be very vulnerable to nest depredation in northwestern Illinois. It appeared that most canopy nests (60–100%) were depredated before young fledged. All five red-eyed vireo nests located were lost to predators before egg-laying was completed. The high depredation levels may reflect the abundance of nest predatory blue jays, crows, and common grackles in the forests of northwestern Illinois. In southern Illinois, crows and grackles only rarely entered the forest, and depredation of canopy nests was less common. Among the species studied, only the wood thrush experienced lower nest predation levels in northwestern Illinois than it does elsewhere in the state.

Managing forests to improve the nesting success of Neotropical migrants may prove to be difficult. Eliminating cowbird feeding opportunities within and adjacent to forests, consolidating the largest tracts, and reforesting some of the

Research assistants check the progress of an understory nest by using a mirror attached to the end of a long pole.

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Ovenbirds have suffered high levels of nest depredation in northwestern Illinois.

longer ravines would increase populations and improve productivity, but nest parasitism and depredation levels would likely remain high. Some form of cowbird and predator control might be necessary in the largest tracts if we are to create a regional network of refuges for breeding Neotropical migrants.

Scott K. Robinson, Center for Wildlife Ecology

Insect Surveys and Immigrant Pests in Illinois

The introduction, establishment, and spread of many common and serious insect pests of agricultural crops has often closely followed human movements and activities. Pests such as the codling moth, Hessian fly, San Jose scale, and Colorado potato beetle either hitchhiked into Illinois along with early European settlers or moved into the state as the native prairies and woodlands were transformed into farmland. Not surprisingly, this invasion of Illinois by non-native insects has continued, resulting in a fairly steady, often unwanted addition to the biodiversity of the state.

Natural History Survey researchers recently assembled an inventory of insect species believed to have moved into Illinois since 1960. The list was compiled through a variety of sources, ranging from literature citations to collection records. Pending verification of these records, investigators have estimated that between 50 and 70 species of insects were first detected in Illinois during the past 33 years.

Some of the new species—such as the western corn rootworm, alfalfa weevil, and Asian tiger mosquito—are causing significant agricultural, medical, and veterinary problems. The Asian tiger mosquito, for example, transmits pathogens that cause human and animal diseases. Others on the list have not yet led to serious problems because they have limited distribution or are uncommon in Illinois but have the potential to cause widespread trouble if changing circumstances favor their increase and spread. For example, the gypsy moth, which defoliates trees, has inhabited Illinois since 1973 but is still fairly confined to northeastern counties. Similarly, although the discovery of the pine shoot beetle in several Great Lakes states during 1992 has caused widespread concern among Christmas tree producers because of quarantine restrictions imposed to prevent its spread, so far the beetle is known to infest only two Illinois counties.

At least eight of the new species are parasites or predators of other insects. Several of these are natural enemies of established immigrant pests and were purposely imported from the pests' areas of origin. Nearly half of the insects new to Illinois since 1960 are of unknown or apparently insignificant consequence.

Modern transportation may make it even easier than in the past for insects to be brought accidentally into Illinois from other parts of the country or from elsewhere around the world. Insects can be inadvertently transported by ships, airplanes, trains, or trucks, and transportation of people and commodities across the country and around the world often involves Illinois, either through the Port of Chicago, O'Hare International Airport, barge traffic on the Mississippi River, or the interstate highways crisscrossing the state.

Today's pest survey and detection programs are certainly complex, and they require the cooperation of many people in a number of government agencies. Illinois participates in a joint federal and state pest surveillance program called the Cooperative Agricultural Pest Survey. This program conducts intensive detection surveys for pests likely to be accidentally introduced and then places the findings in a national computerized database for easy access by cooperators. Interagency research and communication

Gypsy moth larvae, which defoliate trees, are found in northeastern Illinois.

helps to ensure that up-to-date pest information is available to the citizens of Illinois who need it.

Charles G. Helm, William G. Ruesink, and Ellen F. Brewer, Center for Economic Entomology

Research Leads to New Outlook on Soybean Defoliation

Leaf-feeding insects inhabit every soybean field in Illinois and cause varying degrees of crop damage and yield loss from year to year. Current recommendations for management and control of defoliating insects are based on economic thresholds derived from the relationships among insect population levels, the percentage of defoliation caused by those insects, and the decrease in quantity of grain yield caused by the defoliation. However, despite nearly 40 years of research and over 50 published articles exploring these relationships, the physiological effects of defoliation on the soybean crop are only beginning to be understood.

A recently completed two-year, multistate research project was intended to answer some long-standing questions related to defoliation and yield loss and to perhaps improve the rather simplistic criteria currently used for making pest management decisions. Natural History Survey researchers participated in the project, which was funded by the U.S. Department of Agriculture and named the National Investigation of Soybean Stress from Defoliating Pests.

Guided by information provided by a computer program, each group of investigators simulated insect feeding by daily hand-picking various numbers of individual leaflets from approximately 200 plants in each of 24 experimental plots. The leaflets were taken to a laboratory and measured to verify the appropriate levels and rates of leaf removal. Plant samples from defoliated and undefoliated plots were taken weekly from soybean flowering to harvest for growth analysis and measurement of differences in size of plant canopies. Comparative measurements of light interception were also taken weekly to determine differences in the abilities of the altered plant canopies to intercept photosynthetically active radiation, an important component of yield production.

The quantity and detail of measurements taken throughout two growing seasons at all locations avoided some of the pitfalls and inaccuracies of prior studies. The results clearly indicate that yield losses from defoliation are primarily determined by changes in the amount of light intercepted by a soybean canopy. Defoliated canopies intercepted much less photosynthetically active radiation than their undefoliated counterparts, and declines in yields were highly correlated to these differences. The amount of leaf area remaining after defoliation was a better predictor of yield than the percentage of defoliation, which is currently a major component of our management thresholds. These findings have greatly improved our understanding of the impact of defoliation on soybean yield and may well explain the ongoing confusion in the scientific literature concerning previous results of defoliation experiments.

Because the relationship between soybean yields and light interception following defoliation remained consistent between study locations and years, results from this project are valuable to soybean producers throughout the country. Improving the accuracy and reliability of the criteria used to make management decisions may require re-evaluating the approach for assessing insect damage. Specifically, this study suggests that canopy size must be considered when developing management decisions for soybean defoliators. The challenge now is to convert the results of this research into practical management tools, including simple methods that growers and crop consultants can use for assessing canopy size. This will lead to more comprehensive thresholds that can incorporate densities of multiple pests and other plant stresses such as drought and nutritional deficiencies. Greater accuracy in our treatment recommendations for defoliating soybean insects will mean less insecticide use, more grower profits, and reduced environmental and societal concerns.

Charles G. Helm, Center for Economic Entomology

Japanese beetles eat the leaves of soybean plants, thereby decreasing crop yields.

Life in the Mainstream

Looking at the muddy water and muddy banks of a large river, such as the Mississippi or Illinois, one might assume that the river bottom is also muddy. Wading from shore, however, or seeing some of the river bottom exposed during periods of low flow reveals that most of the bed is covered by sand. Where the water flows fast, the sand is formed first into ripples and then into dunes that vary from a few inches to many feet tall depending on water depth and velocity. These are analogous to terrestrial dunes found in the desert, and they are continually moving sand downstream on a long journey to the sea.

Like deserts, mainstream channel beds have traditionally been thought to contain only a few organisms representing a very few odd species, many of which are only passing through on their way to more favorable habitats. The history of desert ecology shows, however, that a close look at a somewhat harsh environment will often reveal a flora and fauna that have unique adaptations to survive and even thrive.

Over the past 10 years, studies in a number of rivers have begun to document a unique assemblage of species that live in or within the shifting, sandy sediments of river bottoms. These species, some of which attain densities of well over 100,000 per square meter, possess unique morphological and behavioral adaptations that allow them to survive in this apparently hostile environment. For example, one species of predatory mayfly larva associated with shifting sands can alter water flow with its head in such a way to excavate a pit in the sand, thus exposing its prey. Unfortunately, virtually nothing is known about other mayfly species that live in these areas although many are considered rare and at least one is listed as a candidate for protection under the Endangered Species Act.

The mainstream channels of most large rivers worldwide have been extensively modified for navigation and flood control. In addition, many of these rivers receive heavy loadings of industrial and domestic sewage. Because the mainstream channel was previously considered virtually devoid of life, there has been little concern until recently about the biological effects of channel modification and pollution. The fact that many of the fish and invertebrates associated with these sandy bottom sediments are now considered rare or endangered suggests that human activities may have had profound effects on these aquatic communities. We know virtually nothing about the ecological relationships among these species or about the importance of these areas to the river ecosystem. A basic assessment of these habitats and how they are affected by impoundment, dredging, and other human activities seems to be an essential part of any comprehensive approach to the ecological management of rivers.

Natural History Survey personnel are currently undertaking such an assessment in the Illinois and upper Mississippi rivers, concentrating primarily on evaluating the impact of navigation dams and flood control levees on the health of mainstream sand ecosystems. Navigation dams, because they lower current velocities and change sediment dynamics for at least part of the year, have profound effects on particle size composition and oxygen conditions within sediments. Levees, because they confine the flow within the mainstream channel during moderate flood events, increase current velocities and rates of sediment transport. The effect of these modifications taken separately or in combination may be stressing mainstream ecosystems beyond their capacity to recover.

Daniel Soluk, Center for Aquatic Ecology

Natural History Survey researchers are studying the ecology of the sandy bottom sediments found in the mainstream channel beds of large rivers, such as the Illinois River.

The rare and potentially endangered mayfly Pseudiron centralis *is associated with the sandy sediments of river bottoms (shown above: adult male). Larvae of this species exhibit unique behavioral adaptations that allow them to live on the shifting sand beds.*

Prairie White-fringed Orchid

The eastern prairie white-fringed orchid was once common in parts of Illinois. In 1927, Herman Pepoon, a Chicago teacher and botanist, wrote that this plant formed a "blanket of white on the moist low prairie." Remaining today are only a small number of scattered populations of this species, which—like the tallgrass prairie it once so abundantly inhabited—has become a victim of human "progress."

One of a few orchids characteristic of the prairies of the central United States, *Platanthera leucophoea* was previously found in marshes, fens, and bogs as well as moist and wet prairies east of the Mississippi River. At present, 54 populations of this orchid remain in the United States, including 21 in Illinois (19 in the Chicago area). The species is currently listed as federally threatened and is considered endangered in Illinois.

Fifty-four populations of the eastern prairie white-fringed orchid remain in the United States, including 21 in Illinois (19 in the Chicago area).

Orchids in the genus *Platanthera* are sometimes called rein-orchids because their lip or spur resembles a rein or thong. This group of tall plants has tuberous roots and long and sometimes dense racemes (inflorescences in which the flowers are borne on short stalks of about equal length at equal distances along an elongated stalk); each flower of the raceme has a long spur. *Platanthera* is the largest genus of orchids in Illinois.

The eastern prairie white-fringed orchid is a stout plant with an angled stem clasped by lance-shaped leaves. The leafy green stalk grows to be 1–3 feet tall, depending on moisture availability, and supports a raceme of 10 to 30 creamy white and deeply fringed flowers. The nectary spur is about 1½ inches long, by far the longest of any member of the genus living in a temperate climate.

Flowering occurs from mid-June to late July, with a few flowers opening each day from the bottom up. Because individual flowers can last up to 10 days, a large plant can be in flower for more than three weeks. At dusk the blooms exude a sweet fragrance that permeates a large area.

The flowers are visited by hawk moths (e.g., the white-lined sphinx), which are attracted by the odor and the promise of sweet nectar. A moth uses its long proboscis to reach the nectar, which is usually held at the base of the spur. In exchange for the nectar, the moth performs a valuable service for the plant—that of cross-pollination. After dipping its long tongue deep into a flower's nectar spur, a moth will fly away with a tiny yellow bundle of pollen attached to its tongue, ready for its next visit to another delicately fringed orchid flower.

The extensive colony that Pepoon commented upon is a thing of the past, and even groupings of a few dozen plants are now extremely rare. Like the prairies of Illinois, however, populations of the eastern prairie white-fringed orchid are being restored in some locations. Two of the present 21 Illinois populations, in fact, are restorations. Patient, persistent, and dedicated volunteers have been hand-pollinating flowers (just in case the moths can't find them), collecting seed for sowing at other sites, and keeping a watchful eye on existing populations, determined that the eastern prairie white-fringed orchid will continue to grace some of the remaining prairies of Illinois.

Teacher's Guide to "The Naturalist's Apprentice" (facing page)

OBJECTIVE to learn to identify a few of the wild orchids that occur in Illinois from their botanical descriptions

SKILLS observation, deduction

VOCABULARY epiphyte, terrestrial, lip, spur, rosette, petal, lobed, botanical

MATERIALS copies of "The Naturalist's Apprentice"

COMMENTS Most people envision orchids as denizens of a steaming tropical rainforest or as inhabitants of the local florist shop. Although the majority of orchids do live in the forests of Central and South America and Southeast Asia, Illinois has its share of wild orchids. Most Illinois species are not as showy as the spectacular epiphytes (growing on something other than the soil surface) of the tropics, but the 35+ species of terrestrial (living in the soil surface) orchids found in Illinois are, nonetheless, treasures.

PROCEDURE Distribute copies of "The Naturalist's Apprentice" and have students complete the worksheet. *Correct answers: A–2, B–3, C–5, D–4, E–1*

EVALUATION Copy the drawings of the various orchids on a transparency and have students try to name the various flower parts. (Hint: The flower of the grass pink orchid is inverted, and the lip sticks up!)

Orchids in Illinois?

Read the botanical descriptions of the plants pictured below and match the correct plant to the description. The diagram shows the typical parts of an orchid flower.

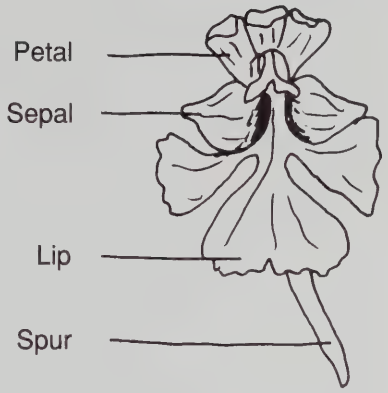
A. **Prairie white-fringed orchid** ___
Lip of flower is deeply fringed and divided into three parts; spur is long and curved.

B. **Rattlesnake plantain** ___
Leaves are in a rosette at base of plant and have distinct white veins; small, globe-shaped flowers are on a long stem.

C. **Nodding ladies' tresses** ___
Long, narrow leaves arise from base of plant; small flowers appear in a spiral on stem.

D. **Yellow lady's slipper** ___
Large leaves occur along stem; petals are narrow and spiral; lip is pouch-shaped.

E. **Grass pink orchid** ___
One grasslike leaf arises from base of plant; lip is three-lobed and erect.



Verticillium Wilt of Maple Trees

Maples are among the most popular shade and ornamental trees in Illinois. Their symmetric crown shape, brilliant fall color, resistance to certain urban stresses, and ease of transplantation have contributed to their popularity for landscaping.

Maples, however, are particularly susceptible to a vascular disease caused by a fungus named *Verticillium dahliae*. This fungus usually resides in soil and attacks trees that are stressed by drought, heat, freezing, or construction injury. Once inside plant roots, the fungus multiplies and is translocated through vascular tissue. The fungal mass, as well as its by-products, will block the water-conducting vessels of a tree and cause wilt symptoms. The disease will kill a tree twig by twig and branch by branch.

This fungal pathogen has a wide host range and causes the same disease in many other ornamental trees, including elm, redbud, and tulip trees, as well as in many agricultural crops, such as potato, tomato, and cotton. Verticillium wilt of trees is peculiar in that it frequently occurs in urban areas but is rarely observed in undisturbed habitats such as natural forests.

Plant pathologists at the Survey have collected various strains of the fungus from a variety of affected trees, mostly maples.

Plant pathologists at the Natural History Survey have been studying this disease for more than 30 years and have accumulated a large collection of various strains of the pathogen from a variety of trees, mostly maples. A recent genetic analysis of the collection assessed the strains' vegetative compatibility; strains that group together are more genetically similar than strains in different groups. This analysis gives researchers insight into the potential sources of this pathogen.

The research showed that most of the pathogen originally isolated from urban trees belonged to one group and differed from strains of the same fungus obtained from potato fields. The results suggest that a main source of the pathogen is the nurseries at which the trees are grown; the trees and their surrounding soil may already contain the fungus when the trees are transplanted into urban areas. Management practices that reduce the pathogen level in nursery stocks would help to control verticillium wilt of urban trees.

Weidong Chen, Center for Biodiversity

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REPORTS

September/October 1993 No. 323

Insect Treasures

Fumes of mothballs permeate Room 296 of the Natural Resources Building. This is the home of the Survey's insect collection, consisting of about 6,000,000 specimens gathered and preserved during the past 135 years by Survey entomologists and others. The fumes keep away living insects that might otherwise eat the pinned collection.

Along with collections at the Smithsonian Institution, the American Museum of Natural History in New York, and the Field Museum in Chicago, the Survey's insect collection ranks as one of the oldest and largest in North America. Pinned, stored in alcohol, or placed on glass slides, the specimens serve as a reference "library" for the identification of insects and related arthropods (spiders, mites, ticks, scorpions, daddy longlegs, and pseudoscorpions). Using these specimens, Survey entomologists each year identify thousands of insects for themselves and other scientists and for the citizens of Illinois, including farmers, homeowners, pest control operators, schoolchildren and their teachers, and 4-H clubs. Because insects are such an integral part of our life, the list of who needs identifications and information pertaining to insects seems to be endless.

In addition, entomologists from around the world frequently borrow specimens from the Survey's collection. In 1993, about 70,000 insects and other arthropods have already been carefully packaged and shipped out on loan or returned to the Survey.

Because it is virtually impossible to collect every type of insect, collections specialize in certain groups. At the Natural History Survey, the outstanding holdings include the stoneflies,

One aisle in the Survey's insect collection, which contains about 6,000,000 specimens.

caddisflies, thrips, some beetle groups, bumblebees, solitary bees, aphids, flies, and leafhoppers. The Survey also maintains the International Collection of Soybean Arthropods, an accumulation of arthropods found on soybeans throughout the world.

Naming and classifying insects (taxonomy) is a challenging component of entomology. For example, there are bees that look like flies, and flies that look like bees. The killer bee is really the same species as the honey bee, albeit extremely aggresive. The identification of the killer bee is determined through protein analysis and minute size differences. In some cases, it may be important to tell the difference between two similar-looking species because one may carry disease, whereas the other may be harmless. The examples go on and on.

Ticks are often sent to the Survey for identification. It is difficult for most people to distinguish among the lone star tick, dog tick, deer tick, and other ticks. It is important, however, to know the difference. The deer tick is a carrier of Lyme disease, a debilitating condition that is treatable in its earliest stages but difficult to diagnose. Accurate identification of the tick species makes the physician's job much easier.

The insect taxonomist's job is to distinguish between species and to describe each insect and its relationship to other insects. Once a species has been identified, additional entomological studies may be conducted. Accurate identification of insects is especially important for research in insect ecology and behavior, integrated pest management, and medical entomology, research areas in which the Survey is active.

The identification of insect species is far from complete. Although approximately 1,000,000 insect species have already been named, scientists estimate that about 9,000,000 more species remain to be identified. New species are continually being named and classified by entomologists at the Natural History Survey and at other institutions throughout the world. In future efforts to identify and

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classify all of the insect species found on Earth, the collection at the Natural History Survey and the taxonomists associated with it will play a valuable role.
K.R. Methven, Center for Biodiversity

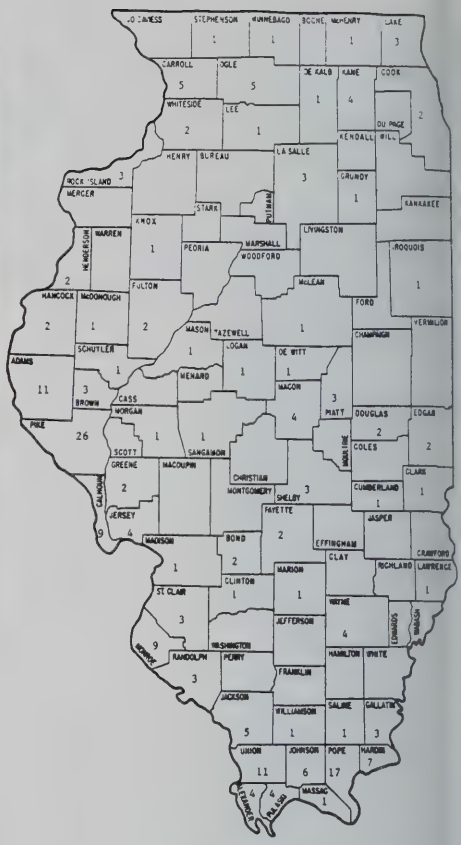
Springs of Illinois

Springs are points at which groundwater flows from the ground in a readily measurable discharge. They can occur in a wide variety of settings. In Illinois, most springs have been found in the Mississippian, Devonian, and Pennsylvanian limestone and sandstone of the Shawnee Hills and along the western border of the state. Additional springs originate from the base of the bluffs along the Fox, Illinois, and Rock rivers. Only a few springs have been found in the central plains of Illinois.

Recently, the Natural History Survey and the State Geological Survey, supported by the Illinois Nature Preserves Commission, cooperated in a program to evaluate the status of Illinois springs. This work involved determining the exact locations of all springs and identifying the fauna and flora within the spring head and its outflow channel. A computerized database, compatible with other state and federal natural resource databases, is being developed to bring together all available information related to each spring.

Springs and their associated outflow channels provide a unique habitat for aquatic animals and plants because of the nearly constant physical and chemical environment. Because of their unusual physical properties and isolation from one another, springs often support a large number of endemic, or at least rare, species.

Salt Well Spring in Gallatin County.



Number of springs found in each county.

At the turn of the century, 88 springs were reported in Illinois. These springs were used for drinking and bathing water or for the perceived health benefits derived from the minerals contained in the water. To date, 200 springs have been entered into the new database from historical, topographic, and personal data sources. A major goal is to determine the location, flow, biota, and water quality of all of these springs.

Seven springs in southern Illinois have been studied intensively to obtain baseline data on their hydrogeology and water chemistry and on the distribution of their fauna and flora. These springs were selected because they are outside areas of intensive agriculture where serious groundwater contamination from fertilizers and pesticides may occur. It was postulated that these springs should show minimal effects of agricultural pollution.

A review of the literature revealed a paucity of information on Illinois springs other than some historical records of their location. Only scattered records of subterranean macroinvertebrates, stoneflies, caddisflies, mayflies, and a few aquatic plants have been reported. No comprehensive study of Illinois springs has ever been performed.

The seven springs studied in southern Illinois were found to be typical of hardwater springs in relation to acidity, oxygen levels, and dissolved solids. The levels of total dissolved solids found in Salt Well Spring and Saline Spring indicate that these highly saline waters emanate from considerable depths within the Illinois Basin. Nitrate levels were extremely low or below the levels of detection in all of the springs studied, indicating no agricultural contamination.

These seven springs offered a unique view of the diversity of the animal fauna of Illinois. More than 85 taxa of animals were collected. At Salt Well Spring, however, which was previously used as a salt source, only a few taxa of macroinvertebrates were collected, probably because this spring contains high levels of total dissolved solids and chlorides, which may restrict biological diversity. At the other six springs, the fauna was

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dominated by non-insectan macroinvertebrates. Turbellarians (flatworms) and amphipods (scuds) were the most abundant organisms throughout the year.

The diversity of oligochaete worms, with 24 taxa collected, proved to be the most surprising finding of the study. *Varichaetadrilus angustipenis*, a worm rarely collected in Illinois, was recorded from six of the seven springs. The collection of *Allonais paraguayensis* in Old Driver Spring in Hardin County was especially interesting because this worm had been previously found only in Louisiana, New York, and South Carolina. Several unidentified taxa were also found, and these may be new species, though additional material is needed before the status of these taxa can be verified.

Old Driver Spring displayed the greatest diversity of macroinvertebrates, with 44 different taxa. Clear Creek Spring in Jackson County was notable for the presence of several interesting oligochaete worms, ostrocods (seed shrimps), and hydrobiid snails.

Plants were very uncommon in the seven springs studied. *Mentha piperita* (peppermint) was collected from the outflow channels of Old Driver and Rose springs, and the bryophyte *Leptodictyum riparium* was collected from the spring head of Old Driver Spring.

The baseline information obtained from these seven springs confirms the need to inventory all other springs in Illinois, to assess the diversity of their fauna and flora, and to obtain water flow and chemistry information.

Donald W. Webb, Mark J. Wetzel, and Loy R. Phillippe, Center for Biodiversity, and Philip C. Reed, State Geological Survey

Changes in the State of Prairies

When European settlers began moving into the middle of North America, they encountered large expanses of land that were devoid of trees but covered with grasses and wildflowers. The settlers used the French word "prairie," which means meadow or field of grass, for this type of landscape, found between Ohio and the

Purple coneflowers at Weston Cemetery Prairie Nature Preserve, McLean County.

Rocky Mountains. The prairie grasses tended to be taller in the eastern part of the region, which received plentiful precipitation, than in the western areas, where rainfall was less abundant. In the area that is now Illinois, about 60% of the land—mainly the northern and central portions—was tallgrass prairie, with the remainder being primarily forest.

Early settlers in Illinois did not generally use the prairie for farming. Because no trees grew on it, the prairie was at first thought to be infertile, and the plows then available could not easily break the dense and deep prairie sod. Soon, however, the settlers discovered that prairie soil is actually among the most fertile in the world, and in 1837, John Deere—who lived in Grand Detour, Illinois—invented the self-scouring, steel-bladed plow, well-suited for breaking the tough prairie sod. Farmers began plowing more and more of the prairie each year.

The conversion of Illinois prairie to farms and other types of land, including urban areas, has been nearly complete. Today, only 1/100 of 1% of the original prairie of the "Prairie State" remains, including a mere 2,352 acres of high-quality habitat. In addition, the prairie remnants, located primarily along the northern and western edge of the state, generally consist of only small, isolated patches. Of 253 prairie sites recently identified, 83% are smaller than 10 acres.

Because they tend to be small and fragmented, the remnants lack the full complement of natural processes that operate in larger, undisturbed prairies. The remnants, for example, might not be subjected to periodic wildfires, which normally keep trees from becoming established in the prairie. Also, human influence has led to ecosystem changes other than outright habitat loss and fragmentation that threaten the biological integrity of some remnants. Drainage of agricultural lands, for instance, can dry out adjacent prairie patches, and pollution by agricultural fertilizers may inadvertently help non-native plants compete with native species that are better adapted to the Illinois environment.

The dramatic changes in the abundance and character of Illinois prairies have taken their toll on the native fauna and flora. A number of prairie species have been extirpated from Illinois within historic time. These include the bison, elk, prairie wolf, mountain lion, and black bear, as well as four species of birds, three insects, and five plants.

One hundred sixteen other prairie species have become so rare that they are considered endangered or threatened in Illinois. This group consists of 95 plants, four reptiles and amphibians, three invertebrates, one mammal (the white-tailed jackrabbit), and 13 birds.

One of the endangered birds is the prairie chicken. Although an estimated 10 million prairie chickens roamed Illinois in 1860, by 1989 fewer than 100 remained. The dramatic decline in the population was largely attributable to the destruction of grassland habitat and the widespread release of pheasants for hunting. Pheasant hens lay eggs in prairie chicken nests, and these eggs hatch earlier than the host bird's, sometimes causing the prairie chicken hen to leave the nest before her own eggs hatch.

Populations of many prairie species that are not threatened or endangered are also declining. Bird population studies,

(Continued on back page)

Bell Smith Springs

The Illinois lobe of the ancient Ozarks boasts two major types of escarpments: protruding sandstone knuckles that undulate in an east-west direction across southern Illinois and limestone escarpments that occur chiefly along the Mississippi and Ohio rivers. These bluffs are often topped by bare ledges of rock, usually sandstone because it is more resistant to weathering than limestone. The dry bluff tops and their canyon wall escarpments are among the outstanding features of the Shawnee Hills in southern Illinois.

One area that demonstrates these features well is Bell Smith Springs Recreation Area, located in the Shawnee National Forest about 19 miles southwest of Harrisburg in Pope County. Named after its former owner, Bell Smith Springs is a world of vertical cliffs, clear rocky streams, outstanding rock formations, and a lush spring flora. Within the park, a trail leaving from Hunting Branch Picnic Area follows an ever-narrowing valley to a spectacular gorge carved by a stream. Upstream of the gorge, the water forms only a meandering trickle, eroding unique formations into a vast sandstone shelf.

Sandstone ledges are windswept, inhospitable places for much of the year. Scorched by the midsummer sun, the bare rocks have surface temperatures that regularly exceed 120°F and are often 40°F higher than the air temperature only a few feet above. Cliff-top vegetation is extremely sensitive and attuned to dramatic fluctuations in moisture. Consequently, most rock ledge plants grow and flower in spring when rainfall is relatively plentiful. Bluets, false garlic, and yellow stargrass occur frequently in shallow depressions and at borders where the sandstone slips beneath the soil of the open oak forest on the bluff tops. The long growing season and the mild winters place this area of southern Illinois well within the range of many upland southern and coastal plain species. The flora is somewhat similar to that of the Piedmont of Georgia and the Carolinas.

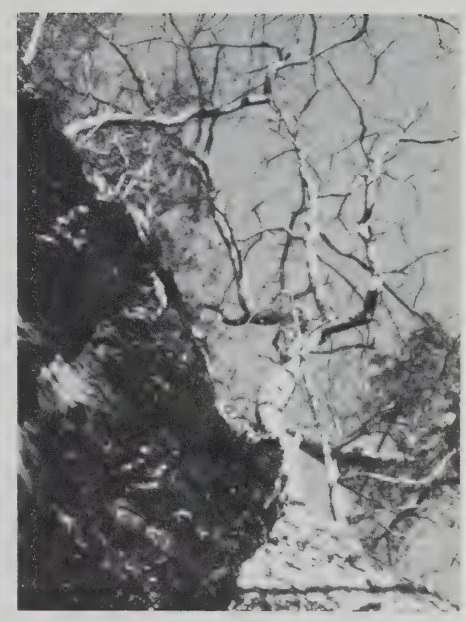
Springtime mini-waterfall originating from small woodland stream.

In some areas blankets of moss and lichens insulate the rock against the extremes of heating and cooling. The moss cushions help to retain moisture, thus reducing the rock temperatures. Light-colored lichens reflect the harsh sunlight and prevent rapid heat loss when temperatures fall. Thus, the fracturing of the rock by expansion and contraction caused by changes in temperature is lessened and its breakdown into soil retarded.

The soil-rock borders of ledges are transition zones, constantly reshaped by the action of wind and water. Dripways originate here, and water flows down the gently sloping rock ledges, forming algae-covered wet streaks. In spring, these dripways become a proving ground for delicate, long-legged craneflies, insects that are far more familiar at porch lights in midsummer than here in early spring. Large, writhing masses or leks of male craneflies roll back and forth across the moist ledges, pausing only when they encounter overlapping ridges of rock that cause a change in direction, or when a female happens along and dives into the amassed males. After a brief but intense struggle within the lek, the female emerges, attached to a large male. Mating ensues rapidly, and the male uses his six spindly legs to form a cage over the female. This strange pair walks to the nearest dripway, and the female, still entrapped by the male's legs, begins laying eggs on the wet algal mat. For the duration of the egg laying, which can take several minutes, the male wards off

Gorge of Hunting Branch, Bay Creek.

Sandstone shelf with dripways (dark streaks) and upland forest.



Cliff edge vegetation seen from valley floor.

Cranefly mating swarm on dripway.

Lichens and mosses covering bare rock.

other males that attempt to reach the egg-laying female by bumping them with his slender body, never relinquishing his claim to the female. Within a few days, the eggs hatch into tiny cranefly larvae that travel down the dripways to small pools carved in the rock, or over the ledge to be washed into other aquatic habitats where they can complete their life cycle. Within weeks the dripways become only dark, dry streaks on the sandstone, providing few clues to the unique relationship that these dripways hold with the craneflies.

In most years orange-tip butterflies, more typical of the western United States, are abundant here. In their relatively short life the adult butterflies have a practical way of mating. They pair overnight, remaining in the open, exposed to cool damp air and thereby losing little water and expending little energy. Their larvae feed on toothwort and other mustards that grow in the adjacent oak woods.

To reach Bell Smith Springs from Harrisburg, travel Route 145 south to Eddyville. Turn north and follow the brown signs to one of the last great wild places in Illinois.

Text and photos by Michael Jeffords and Susan Post, Center for Economic Entomology

Species Spotlight

Lichen Grasshopper

In the Shawnee Hills of southern Illinois lives a grasshopper that is specially suited for living on rock ledges that are encrusted with lichens. The dark brown, green, and whitish markings of the lichen grasshopper make it difficult to see against the mottled surface on which it spends most of its time. When disturbed, it usually flies only a short distance, confident in its ability to camouflage itself after landing. Only when it flies, exposing its shiny, pale yellow hind wings, can this grasshopper be readily seen.

The range of the lichen grasshopper, *Trimerotropis saxatalis,* extends toward the southwest from southern Illinois to Arkansas and Oklahoma, and toward the southeast to the mountains of North Carolina and Georgia. In southern Illinois, it is restricted to the larger sandstone ledges of the Ozark hills, where the grasshopper is at the northern limit of its range.

This species belongs to the insect order Orthoptera and the family Acrididae. The family Latin name means locust, and this species is also known as the rock-loving locust. The "grasshopper" of today, in fact, was called a "locust" in ancient times and was one of the seven plagues of Egypt. Compared to other families of Orthoptera, the Acrididae leap better, fly higher and longer, and feed more voraciously.

The lichen grasshopper, adept at blending into its surroundings.

The lichen grasshopper, like other members of the Acrididae, passes the winter in the egg stage. The female bores a hole in the ground to a depth corresponding to the length of her abdomen. The eggs are deposited one at a time in neat order, and from 30 to 60 eggs are placed in the hole. While the eggs are being laid, a glutinous fluid is emitted around them, and this fluid soon hardens, binding the eggs together into a bean-shaped mass called an egg pod. The hole above the mass is then closed with dirt intermixed with fluid, making the area partially impervious to water.

In April the eggs begin to hatch. The miniature grasshoppers (nymphs) are replicas of their parents, minus the wings and reproductive organs, which will develop later. The grasshoppers are born with a voracious appetite and with a mouth that moves back and forth like the blades of a pair of scissors. Any succulent grass or forb nearby becomes a meal. With the constant eating, the grasshopper soon outgrows its skin and casts it aside, and a new skin takes its place. This process is called molting. After molting five times the nymphs finally become adults, complete with wings.

As you visit the rock ledges of southern Illinois, be on the lookout for the lichen grasshopper, usually not visible until it reluctantly flies to avoid being stepped on.

Teacher's Guide to "The Naturalist's Apprentice" (facing page)

OBJECTIVE to learn to identify a few of the different families of orthoptera found in Illinois

SKILLS observation, deduction, matching

VOCABULARY camouflage, diversified, orthopteroid, ovipositor, tympanum

MATERIALS copies of "Crickets, Grasshoppers, and Katydids."

COMMENTS No summer day is complete without the strident songs of katydids or the snapping, crackling flights of large grasshoppers. Summer evenings, too, have their own orthopteroid symphonies, with each species of cricket trilling out its own characteristic sonata. Such creatures, along with tree crickets, pygmy grasshoppers, mole crickets, and camel crickets (to name a few), make up the order Orthoptera. From an evolutionary point of view, the orthoptera are very generalized types of insects and lack many of the specialized structures found in other insect orders. They have, however, diversified within the order and present a startling array of different shapes and forms. In this installment of "The Naturalist's Apprentice," students will learn to identify a few of the different families of orthoptera found in Illinois.

PROCEDURE **1.** Distribute copies of "Crickets, Grasshoppers, and Katydids."

2. Have students read the list of characteristics under each family and match the descriptions with the animals pictured.

3. Ask students to fill in the blanks in the statements after each list of characteristics.

4. After students have completed the exercise, either in class or as a take-home activity, discuss their results in class and provide them with the correct answers. *Correct answers: A.3. flying, jumping; B.5. camouflage (looking like the background); C.1. soil; D.2. camel; E.4. soil, plant stem.*

Crickets, Grasshoppers, and Katydids

Match the descriptions with the proper drawings and complete the sentences based on your observation of the drawings.

A. Family Acrididae _____
(Short-horned grasshoppers)

Antennae much shorter than body; tympanum (ear) located on first segment of the abdomen.

This insect is adapted for two kinds of locomotion, _____ and _____.

B. Family Tettigoniidae _____
(Katydids)

Long, hairlike antennae; tympanum (ear) located on front leg; hind wings often longer than front wings.

Its appearance suggests that the katydid uses _____ to avoid its enemies.

C. Family Gyrllotalpidae _____
(Mole crickets)

Body covered with fuzz; short antennae; front legs broad and shovel-like.

This organism lives mostly in the _____.

D. Family Gryllacrididae_____
(Wingless, long-horned grasshoppers)

Wings absent; antennae long; rather hump-backed in appearance.

A good common name for this insect might be the _____ cricket.

E. Family Gyrllidae _____
(Crickets)

Long, thin antennae; needlelike egg-layer (ovipositor) at end of abdomen.

The shape of the ovipositor suggests that this insect may insert its eggs in the _____ or in a _____.

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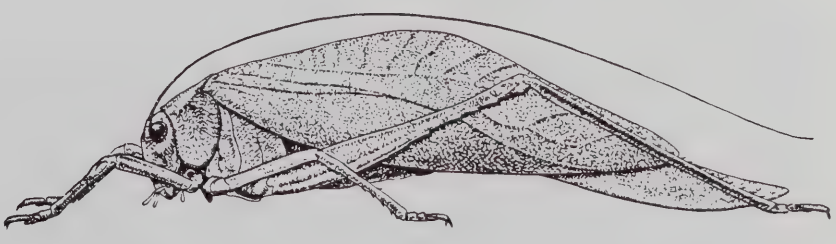

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"The Naturalist's Apprentice" presents educational activities for middle school students. Teachers are invited to photocopy this page for classroom use.

(Prairies—continued from page 3)
for example, have shown a long-term trend of decreasing abundance of nearly all grassland birds, particularly since 1967.

Smaller population sizes make prairie species more vulnerable to genetic problems. When a population declines dramatically, genetic diversity likewise decreases, and deleterious genes are more frequently expressed. Researchers are particularly concerned about potential genetic problems among prairie plants because population sizes for many plant species on prairie remnants may be no more than a few individuals.

Another threat to the remaining prairies of Illinois is non-native species, which may crowd out the native flora and fauna. Studies in Illinois and Indiana show that about 25% of the plant species in some prairie remnants are exotics, including serious non-native pest species such as daylily, teasel, and common buckthorn. Conservationists, in fact, are dedicating more and more time to controlling non-native species that are degrading the remaining prairie habitats.

Throughout Illinois, efforts are being made to restore degraded areas to their natural condition through controlled burns, removal of woody or non-native species, and reintroduction of native plants. Several prairie restorations in Illinois have been successful in establishing high biological, or at least botanical, diversity on formerly agricultural or degraded land. Examples include the Schulenberg Prairie at the Morton Arboretum in Lisle (DuPage County) and the Doris L. Westfall Prairie in Forest Glen Preserve (Vermilion County). Both prairies contain more than 120 species of prairie plants, most of which have been introduced through repeated seeding and the transplantation of seedlings.

Nevertheless, a prairie restoration is generally a poor substitute for an undisturbed, natural prairie because it is difficult for humans to duplicate the complex conditions established by nature. Most prairie restorations, in fact, contain only one-half or fewer of the plant species that would be found in a natural prairie.

Protecting the remaining prairie patches in Illinois is thus crucial for fully preserving this ecosystem and its associated species. Although some of the prairie has already been protected—by being included in an Illinois Nature Preserve, for example—78% is unprotected. Threats to these unprotected areas include highway construction, railroad maintenance, and grazing by domestic livestock. Nine percent of these areas are in immediate danger, and 73% are likely to experience major threats within five years. How our society responds to these threats will determine whether we will be able to hand down to future generations a major component of our natural heritage that provides habitat for numerous plant and animal species that could not otherwise exist in Illinois.

[The preceding article summarizes a technical report written by the Survey's Ken Robertson and Mark Schwartz for the Critical Trends Assessment Project, an effort by the Natural History Survey and other state agencies to document long-term changes in our environment.]

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Lake Trout Spawning in Lake Michigan

In late November, fishermen on Lake Michigan were probably amused and amazed to observe Natural History Survey researchers, dressed in over-sized, padded overalls to stay warm, sitting in their boat and gazing intently at a television set. The researchers were trying to "catch" spawning lake trout on videotape using a remotely operated underwater video camera. The aim of their ongoing research is to determine whether lake trout are spawning successfully in Lake Michigan and, if so, where.

In the 1800s and early 1900s, lake trout reproduction was never in question. Native populations spawned abundantly on numerous rocky reefs throughout the lake, and commercial fishermen harvested up to 9 million pounds of trout each year. Catches suddenly began to decline by 1945, however, and by the early 1950s, the native lake trout had completely disappeared. The loss is attributed to a combination of overfishing and predation by the sea lamprey, which was accidentally introduced into the upper Great Lakes.

Since 1954, government agencies have been working together to restore self-sustaining populations of lake trout in the Great Lakes. Stocking of juveniles has succeeded in establishing populations of lake trout, and lamprey control and fishing regulations have reduced mortality of adult fish. In Lake Michigan, aggregations of ripe fish appear at historic spawning areas each fall, and spawned eggs have been collected at several sites since the 1970s. Nonetheless, recruitment of naturally produced fish into the adult population has not occurred. Consequently, researchers are seeking to determine what factors are impeding the reproductive success of stocked lake trout.

A diver surveys a lake trout spawning reef in Lake Michigan.

To understand what affects lake trout reproductive success, one must first determine where they spawn. Each spawning site that is found teaches us more about the factors that define a spawning site, such as depth, substrate type, interstitial depth, and water quality. This knowledge refines our "model" of what a spawning site looks like, so that more sites can be found. So far, the critical elements of the model include large cobble substrate, deep interstitial spaces into which eggs can fall and be protected from predation, and contour (i.e., the presence of a steep slope nearby).

Researchers at the Survey's Lake Michigan Biological Station have been searching for lake trout spawning areas in Illinois waters for several years. Divers, sonar, and underwater videos have been used to identify and map areas that might be attractive to spawning lake trout. Egg collection devices developed by two Survey researchers have been deployed at various sites to find evidence of spawning

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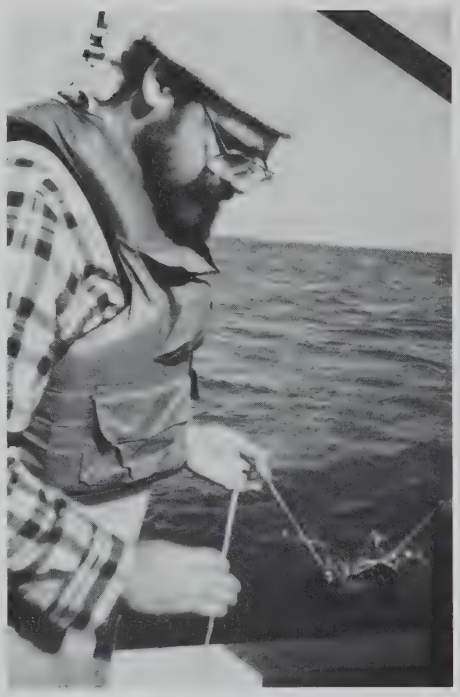
activity. Extensive work over five years at Julian's Reef, a deep, historic spawning site 14 miles offshore, revealed no evidence of spawning, although ripe fish do aggregate at this site each fall. A recent survey of inshore waters less than 12 meters deep revealed seven areas with suitable substrate; eggs were found on five. Eggs were found even on substrate that appeared to be marginal for egg incubation—that is, substrate with interstitial spaces insufficient to hold or protect eggs.

Of particular interest is the presence of large numbers of adult fish at several artificial structures around the south shore of Lake Michigan, including breakwalls and power plant intake lines. Egg collections at one of these sites, the Port of Indiana breakwall, yielded 50 times more eggs than were found at any of the natural sites. Trout spawn on the cobble base of the breakwall, on substrate that appears to be optimal for egg incubation. Clearly, this site provides an ideal opportunity to investigate factors that affect lake trout reproduction. Foremost among these are the effects of exotic species on lake trout egg and fry survival. The cobble near the breakwall is completely encrusted with zebra mussels, which were accidentally introduced into the Great Lakes a few years ago. Forming colonies up to 5 centimeters (about 2 inches) thick, the mussels clog interstitial spaces, and their sharp shells may abrade the fragile lake trout eggs. Most of the eggs collected at this site had been damaged.

In fall, the breakwall site is crowded with carp, another exotic species. Two carp were caught and dissected in the fall, and the stomach of one was packed with lake trout eggs (interestingly, both carp stomachs were also full of zebra mussels). If the eggs are unable to sink into the substrate due to the clogging by zebra mussels, they will be vulnerable to predation by carp and other fish.



Wayne Brofka of the Survey's Lake Michigan Biological Station deploys nets for collecting lake trout eggs.

By spring, the breakwall site is overrun by alewife, a species that was accidentally introduced into the Great Lakes in the late 1920s. These voracious plankton feeders could easily deplete the local waters of the food that lake trout fry need to survive.

The research so far has confirmed that spawning occurs in relatively shallow water and has refined our image of the areas that lake trout choose for spawning. In addition, the research has created a mystery: Why are lake trout so attracted to an "artificial" spawning site? Does this area represent such new and perfect substrate that the lake trout are attracted away from natural sites, or are natural spawning substrates either degraded or limited in availability? Can artificial structures provide a resource to improve lake trout reproductive success? Future research will focus on these questions as well as on the impacts of exotic species as a possible explanation for the failure of stocked lake trout to reproduce successfully.

J. Ellen Marsden, Center for Aquatic Ecology

Mosquitoes and the Flood of 1993

Record rainfall and flooding during 1993 destroyed property and displaced businesses and residents in nine Midwestern states, at an estimated cost of more than $12 billion. The flooding also created excessive numbers of mosquito habitats, ranging from floodplains to stagnant pools, many infused with decomposing plants, various chemicals, and raw sewage. Within a short time, mosquito populations increased dramatically.

People who worked almost around the clock on levees or cleaning up after the flood were easy targets for blood-sucking mosquitoes. Members of the National Guard who worked to save levees throughout the state reported that one of the major problems besides fatigue was the constant biting of mosquitoes from dusk until dawn.

Mosquitoes are a problem not only because they can be a nuisance but also because they can transmit pathogens, such as viruses, that cause disease in people and animals. In consideration of the threat to public health created by the flood-related boom in mosquito populations, members of the Natural History Survey Medical Entomology Program—in conjunction with the national Centers for Disease Control and the Illinois Department of Public Health—conducted mosquito surveillance programs in 36 cities in nine counties along the Mississippi and Illinois rivers during August and September 1993. In each city, Survey staff scouted sites in which adult and larval mosquitoes might aggregate. Many of the sites were located with the help of police officers, firefighters, National Guard members, and others. For two nights in each city, researchers used baited traps to collect mosquitoes, which

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INHS Reports is edited by John Ballenot and printed on recycled and recyclable paper. "The Naturalist's Apprentice" is produced by Michael Jeffords; "Species Spotlight" is written by Susan Post.

Floods and other natural disasters frequently lead to an increase in both the abundance of mosquitoes and peoples' contact with them. Photo by David Gross.

were later separated and identified according to species. Some *Culex* species mosquitoes were sent to Michigan State University to determine whether they were carrying viruses that cause encephalitis; others were assayed for viruses using a new polymerase chain reaction technique developed by the Survey's Medical Entomology Program.

Mosquito production in Iowa and at several locations in Illinois was at all-time highs for several species during the summer of 1993. *Culex tarsalis,* the principal vector of western equine encephalitis, was found in every metropolitan area in Iowa and was collected in large numbers for the first time at several sites in Illinois. None of the mosquitoes of various species that were tested, however, carried viruses that cause encephalitis.

To help homeowners cope with mosquitoes, Survey staff developed a brochure offering important tips for controlling these insects around the house. Titled "What you can do about mosquitoes," the brochure was distributed this past summer to many people in flood-stricken areas; copies will be distributed again before the upcoming mosquito season.

A big question is what will happen to mosquito populations in the future. Many experts suspect that the next few years may surpass even the 1993 season for mosquito production. The risk during these years from mosquito-borne diseases is certainly being taken seriously by both state and federal public health officials.

Hindering efforts to evaluate and address mosquito problems is a lack of scientific information. In many of the flood-affected areas of Illinois, the only mosquito information available is what was collected during the summer of 1993. Although the Illinois Department of Public Health has a surveillance program targeting mosquitoes that transmit viral pathogens, many aspects of mosquito biology and behavior along the Mississippi and Illinois rivers have not been studied. In the future, mosquito experts from the Natural History Survey and other organizations will be seeking to expand basic understanding of mosquitoes and their associated pathogens, develop emergency response strategies for controlling mosquito populations, and provide mosquito-related information and educational materials to the public.

Robert J. Novak and Richard Lampman, Center for Economic Entomology

Exotic Fishes in Illinois

When Stephen A. Forbes, the first chief of the Natural History Survey, conducted statewide stream surveys in the late 1800s, only one non-native species of fish, the common carp, was established in Illinois. By 1979, when Survey ichthyologist Philip W. Smith conducted a survey of the fishes of Illinois, six more non-native species had been introduced to the state. The trend has continued, and at last count, eight more exotic fishes have become established to give us a total of 15 species that were not here prior to human settlement.

Exotic fishes have arrived in Illinois for a variety of reasons. Some species were deliberately introduced into Illinois or into nearby states, from which they found their way into Illinois. The common carp, smelt, and striped bass, for example, were brought to Illinois as food and game fish. The threadfin shad and inland silverside were introduced as forage for game fish. Grass carp were brought from Asia to the Fish Farming Experimental Station in Stuttgart, Arkansas, in 1963 by the U.S. Bureau of Sport Fisheries and Wildlife as a biological control agent for aquatic vegetation. Some of these fish somehow escaped from the farms and found their way to Illinois. More recently, the silver carp and bighead carp, two more species from Asia, have likewise escaped from fish farms in Arkansas and arrived in Illinois.

Other species have arrived accidentally. In the 1820s the Welland Canal was built to allow ships to bypass Niagara Falls and carry cargo from the Atlantic Ocean to the western Great Lakes. The canal has given species native to the Atlantic Slope access to Lake Michigan. The sea lamprey and alewife found their way to Illinois via the canal in the 1930s and 1940s, and the three-spine stickleback and white perch arrived in the late 1980s. Other accidentally introduced species include the goldfish, Rio Grande cichlid, and Oriental weatherfish, which were released by aquarists or escaped from backyard ponds.

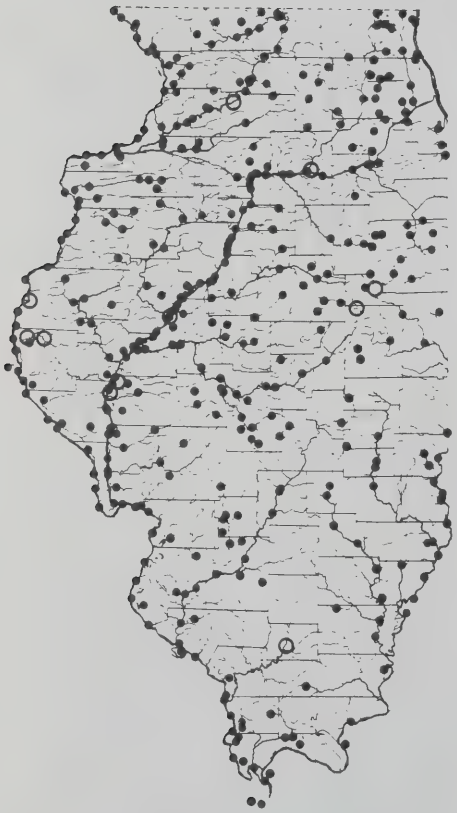
Exotic fishes can dramatically alter

the ecology of aquatic ecosystems. In Illinois the effects have been most pronounced in Lake Michigan. The sea lamprey is believed to have been largely responsible for the decline of the native lake trout, which had played an important role ecologically as a top-level predator. Following the collapse of the lake trout population, the introduced alewife flourished in Lake Michigan. The population explosion of alewives, which feed on plankton, contributed to the decline of several native planktivorous whitefishes. In the 1960s the alewife population became so enormous that it outstripped its food supply. Huge numbers of carcasses were washed ashore along Lake Michigan, causing concern for human health as well as necessitating massive cleanup operations. The alewife remains common in Lake Michigan but no longer reaches huge numbers.

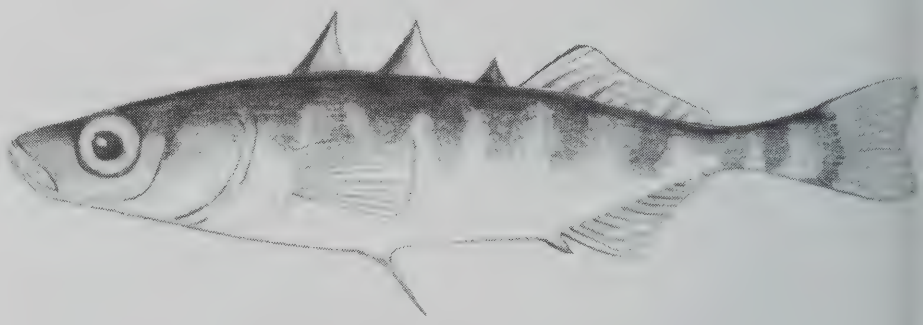
Streams are also affected by exotic species. For example, because carp feed by rooting around in the substrate, they increase stream turbidity and decrease habitat for native species that rely on clear water. Likewise, the grass carp has the potential to do enormous damage to North American stream ecosystems. Introduced to control vegetation in farm ponds, where plants can become too thick to provide a healthy environment for fishes, the grass carp removes stream vegetation that is extremely important to many native fishes, amphibians, and waterfowl species for cover, food, and reproduction.

Native mussels and the larvae of all native fishes rely on planktonic microorganisms as food. Filter-feeding fishes such as the paddlefish and skipjack herring feed on plankton throughout their lives. If the introduced bighead carp and silver carp, both of which are large planktivorous fishes, become common in Illinois, they can be expected to have major negative effects on native species.

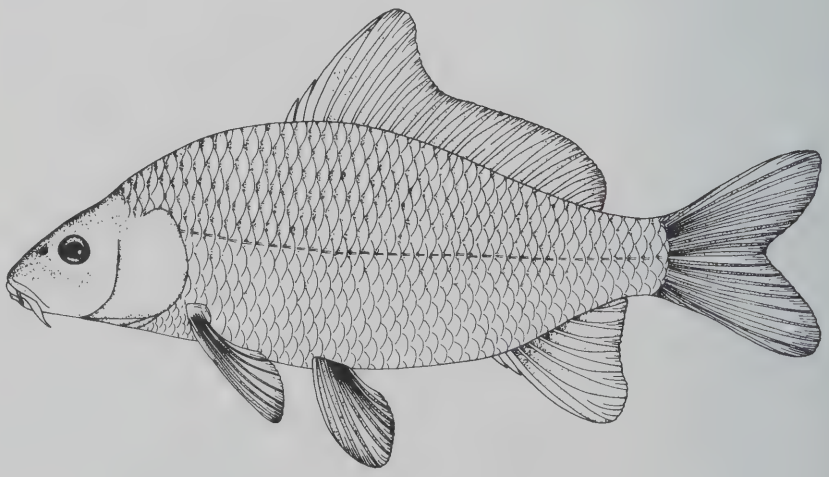
Several other fishes have the potential to become established in Illinois in the next few years. The tubenose goby, roundnose goby, and ruffe are Eurasian species that are established in the Great Lakes and are likely to reach the Illinois portion of Lake Michigan soon. The black carp, another large Eurasian carp, has been imported to the same fish farms in Arkansas that blessed us with the grass, silver, and bighead carps, and it is being proposed for introduction into the Mississippi River in an attempt to control zebra mussel populations. This deliberate introduction may seem to be a reasonable attempt at controlling zebra mussels, but it is likely that the black carp will prefer



Although the common carp was found in few locations in Illinois before 1908 (○), it has been found all over the state since 1950 (●).



The three-spine stickleback arrived in Lake Michigan in the late 1980s.



The common carp was the first non-native species of fish to become established in Illinois. Because carp feed by rooting around in the substrate, they increase stream turbidity and decrease habitat for native species that rely on clear water.

ative mussels over the hard-shelled ebra mussels and will contribute further o the decline of our aquatic ecosystems.

Interactions among species in natural cosystems are very complex, and the esults of species introductions are often npredictable. We can say from experi-nce, however, that introduced species arely live up to the hyperbole that ccompanies their introduction, and sually they damage the environment and esult in economic costs. Unfortunately, n established species is nearly impos-ible to eradicate. The lack of regulations egarding importation of species for quaculture or other purposes makes the ntroduction of more exotic species lmost inevitable.

awrence M. Page and Christopher A. aird, Center for Biodiversity

In the absence of periodic fires, oaks are becoming less common in Illinois forests and shade-tolerant maples (the understory trees in this photo) are taking over in many areas.

Changes in the Forests of Illinois

lthough forests originally covered early 40% of Illinois, today only about 2% of the state is forested. Furthermore, most all of the modern forest is second-y—that is, forest that has regrown in eas where the trees were previously cut own.

In recent years, however, the amount f forest in Illinois has been increasing. rom 1962 to 1985, forest area rose by 0%, due primarily to a reduction in attle production with subsequent version of hayland and pastures to rest. Recent farm programs, such as the onservation Reserve Program and the linois Forestry Development Act, have rovided incentives to allow additional, ss productive farmland to return to rest. The total volume of forest growing ock increased by 40% between 1962 nd 1985, reflecting that growth in recent ears has outstripped harvesting.

The composition of Illinois forests as changed markedly over the past three ecades. For example, the amount of oak-ckory forest, which previously consti-ted more than half of the total acreage, as declined by 14%. This decline is rgely a result of wildfire suppression, which allows the oak-hickory forest to become overgrown, so that the oak and hickory seedlings cannot get enough sunlight to survive. Maple seedlings, by contrast, thrive in the shady environment and grow rapidly once the overstory is removed or dies, resulting in what is known as "maple takeover." Largely because of maple takeover, the number of acres of maple-beech forest rose more than 40-fold from 1962 to 1985, from a very small amount to about 1 million acres, or one-fourth of the total forest area.

Unlike the maple-beech forest, the elm-ash-cottonwood forest suffered huge declines in Illinois from 1962 to 1985. The amount of this forest type fell by half, from one-third to one-sixth of the forest area in Illinois, largely because of the effects of Dutch elm disease and the conversion of forested bottomlands (in which elms often reside) to agriculture.

Maintaining the integrity of Illinois forests is important because they carry a large part of the biological diversity of the state. For example, about 1,600 species of plants (including more than 250 species of trees) are found in Illinois forests, including 175 threatened or endangered species. Likewise, the survival of many species of animals in Illinois hinges on forests, which provide, by one method of calculation, more than three-fourths of the wildlife habitat in the state.

Previous destruction and fragmentation of Illinois forests, however, have reduced the forests' ability to provide suitable hatitat for many species. For example, some animals, such as many large mammals and birds, need large, unbroken tracts of forest for successful reproduction. In addition, forest fragmentation leads to more forest edge, creating more opportunities for edge-adapted species to usurp habitat from species that inhabit the interior of the forest. Fragmentation also increases the likelihood that small, isolated populations will become extirpated.

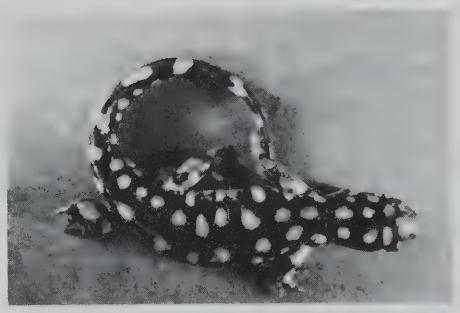
Although few, if any, forest bird species have been eliminated from Illinois to date, a large group of species may be in trouble. If current trends persist, one-third to one-half of the species typical of Illinois forests may **(Continued on back page)**

Species Spotlight

Tiger Salamander

Although they are usually small and remain hidden from casual view, some species of salamanders may be the most abundant terrestrial vertebrates in North America. Salamanders, along with frogs and toads, belong to the Class Amphibia. Amphibians are cold-blooded animals that have a smooth, "naked" skin. They lack a covering of scales, feathers, or fur, and they use their skin and the wet linings of the mouth and throat to take in oxygen and other gases. Amphibian eggs are laid in moist areas on land or in the water. The eggs lack a calcareous shell, and the young develop without the benefit of protective embryonic membranes common to higher vertebrates. Salamanders have a long tail, four legs, and no claws, and they are essentially voiceless, producing only clicking noises, squeaks, or subdued bleats. Although salamanders superficially resemble lizards (which are reptiles), lizards have scales and claws on their toes.

The tiger salamander, one of Illinois' larger salamanders, can reach 1 foot in length and be quite variable, even spectacular, in color. Scattered on a background of olive, black, or brown are many pale brownish yellow or brownish olive blotches, irregular in size and shape. The blotches tend to fuse and form bands on the lower sides and tail, resulting in an animal that may be lightly sprinkled with spots, have tigerlike stripes, or possess a complex netlike pattern. Tigers can be found statewide, even in cities and extensively cultivated regions, but they prefer wooded areas with numerous ponds. Most encounters with humans occur when the salamander accidentally wanders into basements, deep ditches, submerged meter boxes, or similiar pits.



The tiger salamander can be up to 1 foot long.

Tiger salamanders are nocturnal and fossorial (adapted to digging) and disappear with the coming of cold weather by burrowing beneath leaf litter or occupying crevices or other openings in the soil. During the latter part of winter, rains and warming temperatures stimulate them to come to the surface and migrate to breeding ponds. The migration usually takes place at night and over a period of a few weeks. At the breeding ponds, courtship begins with the pair circling and nudging each other on the pond bottom. The males deposit small packets of sperm on top of a jellylike case called a spermatophore. At the height of courtship the female picks up the spermatophore, and the eggs are fertilized inside her body. Two to three days later she lays loose clusters of 25 to 100 eggs, which are attached to twigs, weed stems, or other suitable objects on the pond bottom. After depositing all her eggs, the female leaves the pond. Depending on the water temperature, the eggs hatch in about three weeks.

Tiger salamander larvae grow rapidly and can reach 5 inches in length. They feed mainly on small insects and crustaceans. The yellowish green larvae have a wide golden stripe running the length of their body and large brushy external gills on their backs. Salamander young have true teeth, unlike the tadpoles of frogs and toads.

An adult tiger will eat just about any animal it can overpower and fit into its mouth. Predators of tiger salamanders include herons, turtles, and snakes. Fish are particularly fond of salamander larvae. As with most species, the greatest threat to the tiger salamander is loss of habitat. With a little foresight on our part, though, patches of upland forest containing small temporary ponds can be preserved to continue to provide a home for Illinois' largest land-dwelling salamander.

Teacher's Guide to "The Naturalist's Apprentice" (facing page)

OBJECTIVE for students to learn to interpret information about the reptiles and amphibians of Illinois through reading comprehension and basic mathematics

SKILLS basic math, reading comprehension, deduction

VOCABULARY herpetofauna, Class Amphibia, Class Reptilia, Order Caudata, Order Salienta, Order Testudines, Order Squamata

MATERIALS copies of **Reptiles and Amphibians of Illinois** (facing page)

COMMENTS There are 109 different kinds (species and subspecies) of salamanders, toads, frogs, turtles, lizards, and snakes in Illinois. The salamanders, toads, and frogs occupy the Class Amphibia; the turtles, lizards, and snakes are in the Class Reptilia. To many people these animals are some of the most fascinating creatures found in Illinois. The state's herpetofauna is diverse, ranging from animals that are largely confined to aquatic habitats to those that thrive in the desert-like environment of Illinois' sand areas.

PROCEDURE **1.** Distribute copies of **Reptiles and Amphibians of Illinois.**

2. Have students read the paragraph about Illinois reptiles and amphibians and answer the questions that follow. Basic skills in mathematics will be required to answer the questions.

3. After students have completed the exercise, either in class or as a take-home activity, discuss their answers in class and provide them with the correct answers. The number of correct answers should serve as an evaluation for this edition of "The Naturalist's Apprentice." *Answers: 109, 1823, 2, 2, 69, 2 half, 42, 16.5.*

Reptiles and Amphibians of Illinois

art of the story about Illinois' reptiles and amphibians can be described in numbers. Read the following paragraph arefully and use that information and your math skills to fill in the blanks in the statements below.

> The earliest published reference to the reptiles and amphibians of Illinois was by Thomas Say, who wrote about a turtle 171 years ago. Today we know that Illinois has 1.04% of the 10,484 different kinds of reptiles and amphibians found on Earth. These animals are divided (classified) into the Class Amphibia and the Class Reptilia. The Class Amphibia contains the Order Caudata (salamanders) and the Order Salienta (frogs and toads). The Class Reptilia contains the Order Testudines (turtles) and the Order Squamata (lizards and snakes). In Illinois, there are 19 kinds of salamanders, 21 frogs and toads, 17 turtles, 6 lizards, and 46 snakes. By contrast, Minnesota has 45 types of reptiles and amphibians, and Georgia has 203. Among the reptiles and amphibians are many species that are in danger of disappearing from the wild. In Illinois, 18 species of reptiles and amphibians are considered threatened or endangered and are in need of our protection.

omplete the following statements by using the information in the preceding paragraph:

linois has ____ different kinds of reptiles and amphibians.

he earliest reference to a reptile or amphibian in Illinois was by Thomas Say in _____.

he snakes, lizards, toads, frogs, salamanders, and turtles of Illinois can be divided into _____ distinct classes, each aving ___ orders.

Illinois, there are ____ different kinds of animals that are classified in the Order Testudines or the Order Squamata.

linois has more than ___ times as many kinds of reptiles and amphibians as Minnesota, but only about _____ as any as Georgia.

nakes are the largest group of reptiles and amphibians in Illinois and make up ____% of the total.

urrently, _____% of Illinois' reptiles and amphibians are either threatened or endangered.

Sixlined Racerunner

"The Naturalist's Apprentice" presents educational activities for middle school students. Teachers are invited to photocopy this page for classroom use.

(Forests—continued from page 5)
disappear from many areas. Of special concern are neotropical migrants, which travel to Illinois from wintering grounds in Mexico and Central and South America. These species, which formerly represented more than 70% of the breeding birds in some forested study areas, now account for less than 50%. On small woodlots, the migrants constitute only 25% of all resident birds.

One of the most serious problems facing Illinois forests is the invasion of exotic plants and animals, which may crowd out or kill the native species. Among the most damaging are some shrubs and vines—such as common buckthorn, multiflora rose, autumn olive, and Japanese honeysuckle—that were often intentionally introduced to provide food and cover for wildlife. Another troublesome invader is garlic mustard, which was imported early this century as a food and medicinal herb. A biennial and a prolific producer of seeds, garlic mustard spreads readily into old-growth forest and has become a major threat to the native woodland herbaceous flora during the past 25 years.

The gypsy moth is a notable example of an exotic animal species that is threatening Illinois forests. Although this insect, which defoliates trees, is not yet permanently established in Illinois, male moths have been captured in traps in the Chicago area and in a number of other counties around the state since 1981. Once established in Illinois, this insect invader may devastate oak stands throughout the state.

In contrast to the threat from exotic species, the danger to Illinois forests from pollution seems to be relatively minor at this time. Illinois does not, as of yet, suffer from the same levels of acid rain that have been implicated in the decline of forests in the northeastern United States and northern Europe. Recent evaluations of forest tree health around the state by Natural History Survey staff have shown that Illinois trees are generally in good health compared to trees in some other parts of the world.

[The previous article summarizes a technical report written by Louis Iverson and Mark Schwartz for the Critical Trends Assessment Project, an effort by the Natural History Survey and other agencies within the Department of Energy and Natural Resources to document long-term changes in our environment.]

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January/
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INSIDE

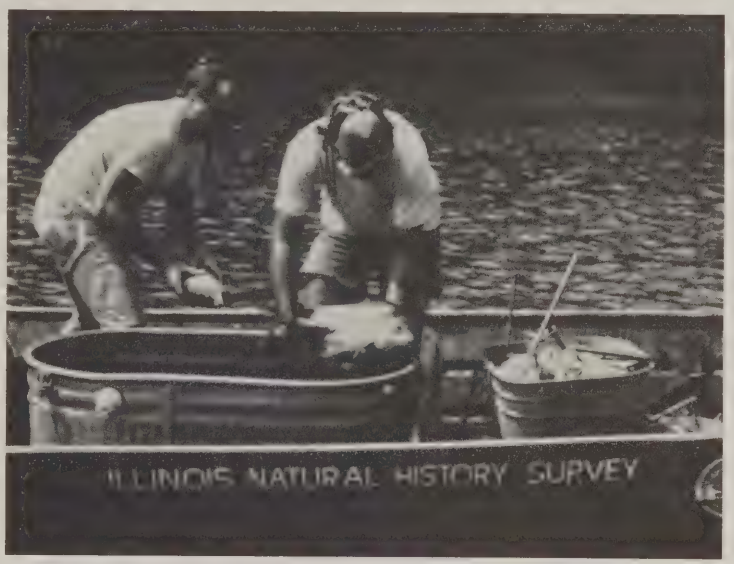
Learning from the Flood of 1993

Although the Flood of 1993 was a $12 billion economic disaster, it was also a once-in-a-lifetime opportunity for Natural History Survey researchers to study the dynamics of large-river ecosystems. Among the Survey workers who monitored the flood and its effects on plants and animals were Charles Theiling and his staff at the Long Term Resource Monitoring Station on the Upper Mississippi River at West Alton, Missouri. They continued to work from their homes after their field station was destroyed by flood waters. Staff at the Survey's research station on the Illinois River at Havana also continued sampling throughout the flooding.

How could the flood possibly be an opportunity? The answer has to do with the nature of field work on large ecosystems. A laboratory scientist can test his or her ideas with carefully controlled experiments, and a field biologist can do likewise in an experimental pond or stream, but a scientist working on a large river usually has to wait for nature to provide the experiment: the strong stimulus that reverberates throughout the ecosystem, affecting the key indicators that are being monitored. The wait can be longer than the scientist's lifetime. In any given year, the chance of a flood as big as the one in 1993 has been variously estimated as 1 in 100 to as little as 1 in 500.

The greatest legacy of the flood may be new attitudes and policies regarding floods and floodplain management.

Important ideas in large-river ecology currently are described in the Floodpulse Concept, developed by Survey aquatic ecologists Peter Bayley and Richard Sparks, in cooperation with Wolfgang Junk at the Max Planck Institute in Germany. If the tenets of this concept are correct, there should be an exceptionally large 1993 year class of fishes (a "year class" is the group produced during a given year) that nest in the shallow margins of the Mississippi River floodplain (including largemouth bass, crappies, and sunfishes) or on flooded vegetation (grass pickerel, for example). Indeed, relatively large numbers of juvenile fish from 52 species and 15 families were collected by Survey researchers during the summer of 1993 on the Mississippi River floodplain near Grafton, suggesting that some fishes extended their spawning season as flooding continued. The flood lasted an unusually long time, cresting four times and falling very slowly, so the juveniles had plenty of time to grow before they had to retreat to the permanent channels and backwaters (see hydrograph, page 2).



Crew netting fish on the floodplain of the Upper Mississippi River. Photo by Charles Theiling.

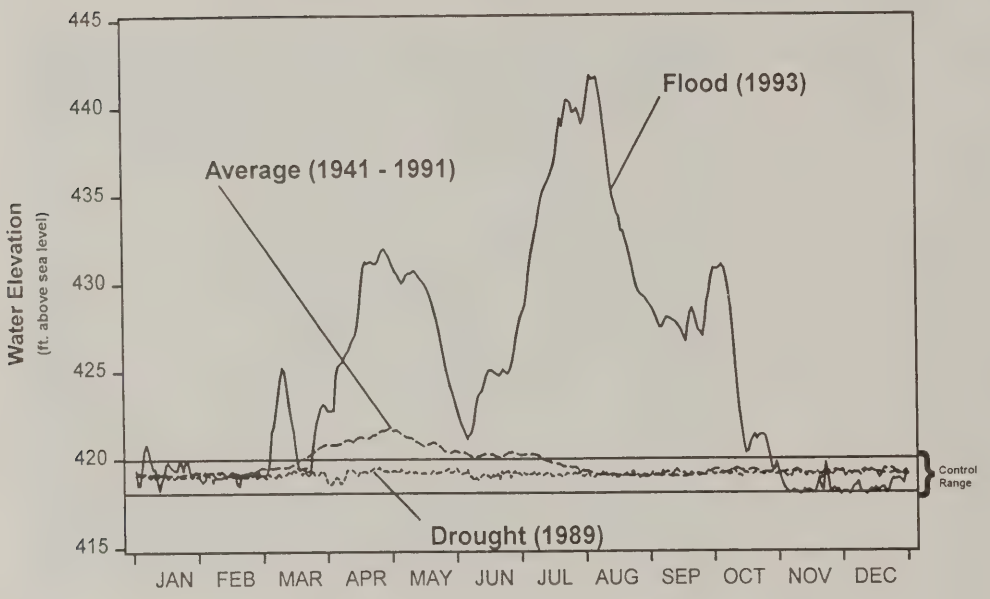
Unfortunately for the fish, the Corps of Engineers took the unusual step of lowering the river in November and December be-

Floods

continued from page 1

low the minimum level normally maintained for navigation. This drawdown may have forced fish out of favorable wintering areas or stranded them in shallow pools, which could have frozen all the way to the bottom during winter. Fish sampling in 1994 will indicate whether the exceptionally abundant 1993 year class, which could provide large adult fish for several years to come, was drastically reduced by the drawdown.

Water levels were drawn down to assist levee districts that remained flooded because the land within the levees is actually below the low water level of the river. In other words, without levees and pumps these areas would be permanent backwater or floodplain lakes. An important policy issue is whether government should continue to subsidize dryland agriculture in former lakes and floodprone areas through price supports, disaster relief, and maintenance and rebuilding of levees and pumping stations, in preference to aquaculture, flood-adapted fish and wildlife production, or at least a more flood-adapted form of agriculture.



Changes in the level of the Mississippi River at Grafton, Illinois, during 1993. Average water elevations and levels during drought are shown for comparison. In November and December, the Corps of Engineers reduced the water elevation below the normal level maintained for navigation to help drain water out of breached levee districts.

Some of the beneficial effects of a natural floodpulse do not occur when levees fail and water suddenly rushes onto the floodplain. A slow, natural rise allows terrestrial animals, such as deer and turkeys, to vacate to higher ground and creates a moving zone of shallow water that advances across the floodplain. In this zone, nutrients can be released from the newly flooded soils, stimulating production of microscopic animals, just when they are needed as food by larval fishes.

Unfortunately, several pest species, including some mosquitoes that are vectors of human disease (see November/December issue of *INHS Reports*) and the newly introduced zebra mussel (see article on page 3), were aided by the flood. The larvae of several species of mosquitoes do well in temporary pools and in water-filled containers, abandoned tires, and tree holes, where their predators (primarily other insects and fish) cannot enter or survive.

The understory of the floodplain forests has been temporarily eliminated by the protracted flood, and gaps may even open in the canopy as some individual trees that have been weakened succumb to insects or disease. In compensation, the absence of shading and other forms of competition will enable cottonwoods and perhaps many other species to germinate and grow, thereby rejuvenating mature plant communities. In some places along the Missouri River, the river itself was rejuvenated where it broke levees that are unlikely to be rebuilt (at least in the same place) and scoured new basins and channels to replace those that had been lost to sediment accretion.

The greatest legacy of the flood may be new attitudes and policies regarding floods and floodplain management. Despite the expenditure of billions of dollars on flood protection over the past century, the average annual costs of flood damage have been rising, even when adjusted for inflation. The levees and pumping stations themselves become part of the loss during a major flood and are used to justify increased expenditures on yet higher levees and upstream flood storage reservoirs—a fact that has prompted the White House to reexamine the nation's flood management programs. In a few months, the Interagency Floodplain Management Task Force will make recommendations to the president regarding modification of federal programs to better protect life, property, and Upper Mississippi River ecosystems. The addition of ecosystem protection to the list of goals is based on increasing public and governmental appreciation of the role of natural floodpulses and value of natural services provided by rivers, floodplains, and wetlands. These services include production of fish and wildlife; preservation of biodiversity; water purification; self-repair following natural or human disturbance; and, especially after 1993, the conveyance, storage, and moderation of floods.

Richard Sparks, with information provided by Charles Theiling, Robert Maher, and John Nelson, Center for Aquatic Ecology

Zebra Mussels in Rivers

"There is a continuous mat about 2 inches thick on the bottom, and if I dig my fingers underneath, I can lift it up like a carpet," said Scott Whitney, whose voice came over the speakerphone on the Natural History Survey boat *River Diver*. Scott—who was 30 feet under water and breathing through an umbilical hose—was describing a layer of zebra mussels at the bottom of the lower Illinois River, near the confluence with the Mississippi, in August 1993.

Scott had found something that was not supposed to happen: zebra mussels had colonized a mud bottom, instead of attaching to rocks, logs, and other solid objects with their sticky byssal threads. Although clumps of zebra mussels the size of baseballs had been observed on mud and sand in the Great Lakes, nothing like this carpet containing up to 94,000 small ($^5/_{16}$ inch) mussels per square meter had been observed. This was the first documented population explosion of zebra mussels in the Mississippi River drainage.

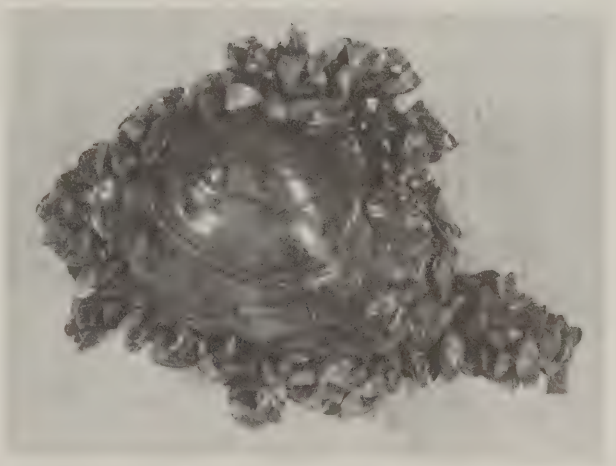
Water users along the lower Illinois and Mississippi rivers were suddenly scrambling to install chlorine injection devices to kill incoming larvae and adult mussels. Many downstream users had thought the mussels would invade and affect upstream reaches first, gradually progressing downstream from Chicago, where canals link source populations in Lake Michigan to the river (see *INHS Reports* nos. 298 and 310, June 1990 and October 1991, for more information).

In fact, sampling by Survey staff at five study sites along the Illinois River (see map, page 4) showed that concentrations of zebra mussels in the fall of 1993 were greater downstream than upstream. The average zebra mussel density was 61,000 per square meter at Grafton (at river mile [RM] 5.5, near the confluence with the Mississippi), compared with 1,800 per square meter at Peoria (RM 162.3) and less than 1 per square meter at Chillicothe (RM 181.0). Likewise, whereas 99% of native freshwater mussels at Grafton were infested with zebra mussels, only 3% at Chillicothe were affected.

The most likely explanation for the greater number downstream is that a pulse of zebra mussel larvae from southern Lake Michigan or from the upper river was carried far downstream (perhaps by the Flood of 1993; see related article on page 1) during their 10- to 30-day larval period before they settled on the bottom. Where the mussels eventually settle out is determined by the velocity of the river current and the duration of the larval stage. That the mussels in the lower Illinois River at Meredosia and Grafton came from one pulse was supported by their uniform, small size; practically all were less than 15 millimeters. If the current velocity during the period of larval release is less in 1994 than in 1993, the upper or middle sections of the river could be seeded, so much of the river could become carpeted with zebra mussels in just two years.

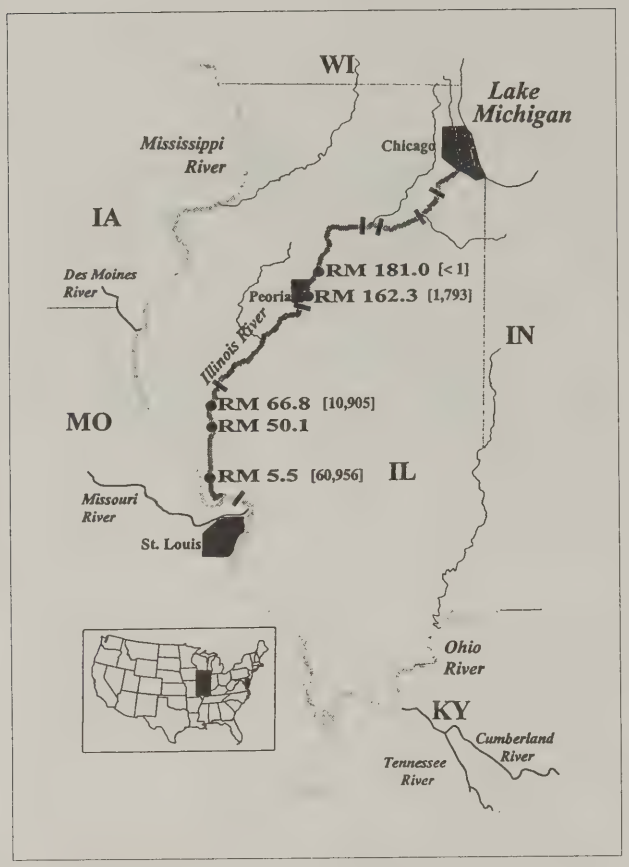
What effects will the zebra mussels have in the Illinois River? This is an important question because it portends what could happen to the rest of the Mississippi drainage. Waterway shippers are likely to face rising costs because masses of attached zebra mussels can plug engine cooling systems and increase the water resistance of boat hulls, thereby increasing fuel costs and maintenance costs per mile. Water users will have to install and operate chlorine injection devices to keep zebra mussels from clogging intake pipes; estimated annual costs for chlorine alone are several hundred thousand dollars each for some industries along the Illinois River.

The environmental effects of zebra mussels include direct effects on native species. Zebra mussels threaten native mussels, clams and snails, and the animals that depend upon these native species for food, shelter, or egg-laying sites. Natural History Survey divers have found freshly dead native mussels (with meats inside) so heavily infested with zebra mussels that their shells could not be forced closed. Others were held shut by tufts of



Top:
Exposed side of a native floater mussel completely encrusted with zebra mussels.

Bottom:
Side of the mussel that rested on the river bottom, the only part not encrusted. The mussel was alive when collected; the shell cracked during preservation. Photos by Scott Whitney.



Locations of five zebra mussel study sites on the Illinois River. RM stands for "river mile" and refers to the distance in miles from the confluence of the Illinois and Mississippi rivers. The average density of zebra mussels at each site is shown in brackets (values indicate the number of mussels per square meter).

byssal threads attached to both shells. These adverse effects on native mussels not only threaten biological diversity (there are 23 species of native mussels in the Illinois River) but also endanger 10,000 U.S. jobs and $80 million worth of shell exports (the Pacific cultured pearl industry uses shell from North American freshwater mussels to form nuclei for cultured pearls).

Zebra mussels also have complicated effects on water quality. Although zebra mussels tend to improve water quality by filtering organic matter, they also remove oxygen from the water and create waste products, whose breakdown uses up even more oxygen. Oxygen levels can drop so low that native animals, including fish, can be severely stressed or even killed. Recent gains in fish and wildlife populations resulting from improved water quality may be set back drastically.

Could zebra mussels at the densities occurring in the lower Illinois River significantly lower oxygen levels in the river? A definitive answer requires intensive field measurements of both zebra mussel populations and oxygen uptake rates, and no such coordinated measurements have been taken. Cursory measurements and back-of-the-envelope calculations indicate that problems are already developing, however. Oxygen levels recorded by Natural History Survey staff and others last fall in the Illinois River near Grafton were well below the Illinois water quality standard for dissolved oxygen and well below the levels recorded in July and August 1991. In most locations, oxygen levels decreased with depth, indicating a strong oxygen demand coming from the bottom where the zebra mussels are. It is possible that receding flood waters carried oxygen-demanding organic matter into the river, but calculations by Survey staff and others indicate that the carpet of zebra mussels also had an effect, which would be even stronger under low-flow conditions, when the waste-diluting capacity and oxygen resources of the river are lowest. With severe depletion of oxygen by zebra mussels, portions of the river could revert to the foul, lifeless condition that occurred just after the turn of the century when excessive organic wastes from Chicago used up all the oxygen for 100 miles downriver.

It may be possible to reduce zebra mussel populations in some rivers without harming native aquatic organisms by focusing on the weak link in the mussel's life history: the larvae. In contrast to the larvae of native mussels, which attach to fish and are carried upstream as well as down, zebra mussel larvae drift downstream only. Because zebra mussels live only four or five years, and adults do not move on their own more than a few feet upstream, dense beds of zebra mussels persist only if they are reseeded by larvae from upstream sources. Reduce the upstream supply of larvae and you reduce the downstream populations, perhaps triggering reductions that would cascade downstream. If most of the larvae in the Illinois River come from southern Lake Michigan or the Chicago canal system, the supply could be interrupted by thermal barriers in upstream lock chambers. There is plenty of waste heat from industrial and municipal sources in Chicago, and the heat could be dissipated within the canal system, leaving no residual toxicity, as occurs with chemical agents that must be detoxified. Pleasure boats and the lock mechanisms could benefit from the warm-water treatment, which would kill attached adult mussels as well as any larvae that were in the water, and adult mussels would be less likely to hitchhike to distant parts of the inland navigation system.

Measurements should be taken and predictive models developed as quickly as possible to quantify the effects of zebra mussels more precisely, not just for the sake of the Illinois River but because what happens to the Illinois River is likely to happen elsewhere as well. The place to try out techniques for managing zebra mussels in rivers is the Illinois, where the first documented population explosion in the Mississippi River drainage is well under way.

Richard Sparks, Center for Aquatic Ecology, with information supplied by Thomas Butts, Illinois State Water Survey, and Scott Whitney, Sharook Madon, Douglas Blodgett, and Eric Ratcliff, Center for Aquatic Ecology

Stoneflies of Illinois

Stoneflies are a small, diverse group of insects whose immature stages are entirely aquatic. Some 550 species in 91 genera are known from North America, and eight of the nine North American families are found in Illinois. Stoneflies are well known to fly-fishermen, who frequently tie flies imitating adult or larval features, as depicted in the film *A River Runs Through It.*

Stonefly larvae are an important component of stream ecosystems. Some species are top invertebrate predators, and others feed on coarse particulate organic matter. Many serve as an important food source for other animals. Because stoneflies are intolerant of a variety of environmental perturbations (such as excessive siltation, temperature alterations, and acidification), researchers often use them to monitor the health of aquatic systems.

Most stoneflies complete their life cycle in a single year, but several larger species can take two or more years. Often there is an egg or larval diapause, a period during which growth and development is suspended. Adults are short-lived, surviving only a few days to a few weeks.

Among many stonefly species, individuals drum to find suitable mates. The male beats his abdomen on vegetation, and the female responds in kind, enabling the male to locate the female. Following mating, the female lays her eggs in a stream, where the life cycle begins again.

Twenty species in Illinois emerge as adults during the dead of winter. The presence of these small, black insects during winter has confounded many a naturalist. From November through March, one can easily collect these "winter stoneflies" as they bask in the sunlight on bridges, crawl across stones lining creek shorelines, or hide in dry leaf packs caught in the brush along a brook.

The Natural History Survey has played an important role in stonefly systematics. Theodore H. Frison, the chief of the Survey from 1930 to 1945, authored two Survey bulletins, published in 1929 and 1935, on the stoneflies of Illinois; a third Frison bulletin, published in 1942, summarized much of the knowledge of the North American species. Survey entomologist Herbert H. Ross, with William E. Ricker, provided detailed revisions of important winter stonefly genera in the late 1960s and early 1970s. The thousands of specimens collected by Frison, Ross, and others have given the Survey an exceptional record of species diversity and distribution over time, especially in Illinois.

While examining the Illinois records recently, Survey staff were surprised to find that about 40% of species were collected from three or fewer locations. A study was begun to find out why each of these species was apparently rare in Illinois and to document the current status of the Illinois stonefly fauna in relation to environmental perturbations over the past 50 to 70 years.

Recent collections have yielded some interesting results. For a number of species, the historic and present distributions remain similar; historically abundant species remain abundant, and several species that were previously known from a single locality are still found only at that one location. Some species seem to be more widely distributed today than in the past, but this finding is probably due to undersampling in the past.

Unfortunately, many species, some previously widespread, have not been collected recently.

Stonefly adults congregating on a tree trunk on a spring day. Adult stoneflies are generally short-lived, surviving only a few days to a few weeks.

Because stoneflies are intolerant of environmental changes, researchers often use them to monitor the health of aquatic systems.

Stoneflies

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Future efforts will concentrate on finding these species. Already there is evidence that some species have been eliminated from the Illinois fauna. Conversely, a few species have been added to the Illinois species list from new collections and from systematic changes.

Survey staff now have records of 65 species of stoneflies in 26 genera from Illinois. Data on Illinois specimens have been entered into a computer database, and work continues on the remainder of the stonefly collection. More than 8,500 records have been entered, including more than 3,200 from Illinois. When all the data are entered, the stoneflies will be the first insect group at the Natural History Survey for which all collection information will be accessible by computer.

Mitchell A. Harris and Donald W. Webb, Center for Biodiversity

More than Prairie Chickens

From the 1860s through the 1950s, the number of prairie chickens in Illinois plummeted because of widespread conversion of prairie to farmland, heavy hunting pressure, and other factors. To help prevent these birds from being eliminated from the state, grassland sanctuaries were established beginning in the early 1960s in Jasper and Marion counties.

Young Northern harriers in a nest on a prairie chicken sanctuary in Jasper County.

These sanctuaries have provided much-needed habitat not only for prairie chickens but also for other grassland species. Within the past five years, in fact, the list of responding grassland birds has grown such that the prairie chicken is no longer the only focus of management and research efforts.

Some of the responding birds are rare species. Among the 12 species of threatened or endangered birds that are year-round residents in Illinois, five are dependent or semidependent on grasslands, and all five are now found on the sanctuaries. In addition to the prairie chicken, these species are the loggerhead shrike, Northern harrier, short-eared owl, and barn owl.

Prairie chickens and loggerhead shrikes were permanent residents when the first sanctuaries were acquired (1962–1964) and seeded to cool-season grasses and forbs. For 20 years, Northern harriers and short-eared owls were observed only as winter foragers. The first harrier nest was found in 1983, and nesting by short ears began with a surge of at least 13 nests in 1990, along with at least eight more harrier nests. There was widespread nesting by both species again in 1993 on the sanctuaries in both Jasper and Marion counties. These nesting concentrations in 1990 and 1993 were the largest known to exist in Illinois. Harrier nesting on sanctuaries has now been documented for five consecutive years.

Although there were no confirmed sightings of barn owls on the sanctuaries from 1962 through 1992, nesting by barn owls began in 1993 in an artificial nest box. Only four other active nest sites were known in the state in 1993.

Sanctuary grasslands provide a vital source of prairie voles, southern bog lemmings, and other prey for these rare harriers and owls. During winter sunsets, possibly 75 or more harriers and 30 short-eared owls can be observed in Jasper County alone—one of the largest concentrations in Illinois. Sometimes a few prairie chickens are included in the mix as they go to roost.

Threatened and endangered birds that are present on the sanctuaries during the spring and summer breeding season have long included upland sandpipers and Henslow's sparrows. In 1990, two apparently successful nests by king rails provided another first in the database for sanctuary breeders. King rails were officially listed as threat-

Five species of threatened or endangered birds that are year-round residents in Illinois are dependent or semidependent on grasslands. All five are found on the sanctuaries.

ened in Illinois in January 1994. Two other wetland birds, the American bittern and the yellow rail, are recent additions to the list of endangered birds on the prairie chicken sanctuaries, but their secretive behavior coupled with their preference for wetland habitat makes verification of nesting difficult.

Removal of tall wooded fencerows on or bordering sanctuary habitat has created additional, vital open space for threatened and endangered species. Another change, near the Jasper County sanctuaries, was the creation of Newton Lake in 1977 by Central Illinois Public Service Company. Bald eagles, ospreys, and even sandhill cranes (all endangered) can now sometimes be observed in the area. Other, more abundant species have also benefited from these changes in the landscape. For example, mallard nesting, which began on sanctuary grasslands in 1977, is now common.

The Nature Conservancy, the Illinois Department of Conservation, the Natural History Survey, and other organizations have worked cooperatively for three decades to develop the Illinois prairie chicken sanctuaries, as part of broader efforts to preserve the full array of biological diversity in Illinois. Unfortunately, the basic minimum goal of land acquisition for these sanctuaries, 1,500 acres in each of the two counties, is barely two-thirds accomplished. Needed additions to the sanctuaries can now be expected to benefit much more than prairie chickens.

Ronald L. Westemeier, Center for Wildlife Ecology

Female Northern harrier defending nest site.

Aphids and Crop Disease

Barley yellow dwarf, the most widespread and economically important viral disease of cereals worldwide, can cause major yield losses in the Midwest in epidemic years. This disease affects over 100 species in the grass family, including barley, wheat, oats, sorghum, rye, corn, rice, and a wide variety of wild grasses. It causes stunting and yellowing of plants, with more severe symptoms and greater yield loss the earlier the plants are infected.

The virus that causes barley yellow dwarf cannot be transmitted by seed or mechanical means but only by the feeding of about 20 species of aphids. One species in particular, *Rhopalosiphum padi*, is responsible for most of the infections of the most common strain of the virus (the PAV strain) found in Illinois. Aphids become infective with the virus after feeding for many hours on an infected plant. Once the virus is acquired, the aphid vector is potentially infective for life.

Understanding the dynamics of virus spread within a field is key to constructing effective control strategies. To better understand these dynamics, a multiyear, multidisciplinary project, funded through the U.S. Department of Agriculture, has been conducted by Michael E. Irwin, Catherine E. Eastman, and Gail E. Kampmeier of the Survey's Center for Economic Entomology, along with Adrianna D. Hewings of the USDA's Agricultural Research Service. The research team hypothesized that the dynamics of barley yellow dwarf spread is different in fall-planted crops, such as winter wheat, than in those planted in spring, such as spring oats. The investigators set out to test whether fall infections have a greater impact on within-field spread than spring infections.

In both the fall and spring, infective and noninfective aphids fly into a newly planted field, feed, and perhaps deposit live young, which may then develop on a plant that was previously infected with the virus by a transient winged aphid. The developing aphids may thus acquire the virus from the host plant and

Student, Marianne Hartman, checking suction traps for aphids.

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Aphids

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may subsequently spread the virus by feeding on neighboring plants. The difference between the fall and spring is the early presence in the fall-planted crop of a pool of potentially infective and colonizing aphids that have left senescing crops and grasses. Early infections transmitted by these aphids will have the greatest impact on the severity of the disease.

The research team found that fall infections were spread by colonizing aphids to neighboring plants but that symptoms only showed up with the flush of new growth in the spring. There is little evidence that winged aphids acquire the virus from this source in the spring and transmit it to other plants within the field. Infective winged aphids arriving in the spring may transmit the virus to new plants, but the impact is minimal in the maturing crop.

Aphids are generally not able to overwinter on the crops in central Illinois. During three years of experiments, oats were planted near the end of March, and the first few winged aphids were trapped during the first or second week of April, when the plants were barely out of the ground. Aphid flights peaked between early May and early June. During the spring, between 5 and 20% of the aphids trapped flying over the experimental fields were infective with the PAV strain of the virus. Epidemics in spring oats depend on the early arrival of infective aphids and subsequent colonization of infected plants by nonwinged aphids that will spread the virus to neighboring plants. When aphid flights peaked in June, the oat plants were already too mature for the virus to have much of an impact on yield. However, large flights of aphids in early May in two of the three years caused these years to be considered epidemic for barley yellow dwarf.

Epidemiological information is essential to develop truly effective control strategies for barley yellow dwarf. One essential ingredient is a knowledge of the type of vector movement during epidemics; without this information, management tactics cannot be targeted on the weakest links of the epidemiological cycle. This information must be understood in the context of the influences it has on epidemics under different management systems. The key to good control is to integrate the various tactics into a cohesive strategy that ultimately reduces the impact of the virus on crop yield—not only over the short term but also over successive seasons—while safeguarding the environment and wildlife.

Michael E. Irwin and Gail E. Kampmeier, Center for Economic Entomology

The key to good control is to reduce the impact of the virus on crop yield while safeguarding the environment and wildlife.

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INSIDE

Developing a Wetland Conservation Plan

Wetlands, such as marshes, bogs, and shallow ponds, are an integral component of our landscape. The environmental functions of wetlands include reducing the severity of flooding, helping to recharge groundwater and surface water supplies, improving water quality, and furnishing habitat for fish and wildlife. Wetlands also provide educational, research, recreational, and aesthetic opportunities for people.

Although wetlands once covered an estimated 9,400,000 acres in Illinois, a recent inventory revealed that only about 918,000 acres of natural wetlands remain, including only 5,000 undisturbed acres. Illinois has thus lost more than 90% of its original wetland acreage. Activities that have contributed to wetland loss or degradation in Illinois include urban development, agricultural activities, forestry practices, channelization of rivers, pollution, sedimentation, and the invasion of non-native species.

Illinois has lost more than 90% of its original wetlands.

In recent years, Illinois has been at the forefront of nationwide efforts to inventory and protect remaining wetlands. Information from the Illinois portion of the National Wetlands Inventory—an effort coordinated by the Illinois Department of Conservation (IDOC) and the U.S. Fish and Wildlife Service—has been used to develop a wetland geographic information system for the state. This computerized system, operated by the IDOC and the Natural History Survey, stores data on each of the wetlands in Illinois and generates detailed wetland maps. In 1989, the state legislature passed the Interagency Wetland Policy Act, the first regulatory program in Illinois dedicated to the protection of wetlands. The Act officially established the goal of no net loss of wetland acres in Illinois. Recently, Governor Edgar's Water Resources and Land Use Priorities Task Force and the IDOC's Conservation Congress have looked at wetland issues in a more general context of ecosystem management and protection.

Following principles set forth by the governor's task force, the Conservation Congress, and the Interagency Wetland Policy Act, Sharon Baum and Tony Shaffer of the Natural History Survey are working with Marvin Hubbell of the IDOC to develop a comprehensive plan for conserving the state's remaining wetlands. The Illinois Wetland Conservation Strategy is being developed in two phases. Phase I includes an analysis of the status of the wetlands in Illinois and a thorough examination of relevant federal, state, and local laws and authorities. Another component of phase I is a survey of federal and state resource professionals, a survey that has already led to a preliminary list of key wetland programs and an evaluation of their strengths and weaknesses.

The beauty and the important environmental functions of wetlands have been increasingly recognized in recent years.

The primary goal of phase II will be to prepare a comprehen-

Wetlands

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sive report with detailed recommendations for implementing the conservation strategy. Helping to shape the report will be a public advisory committee whose members will represent diverse interests, including agriculture and other industries, environmental organizations, sportsmen, local units of government, and scientists. This committee will focus on protecting ecological and biological integrity, balancing the rights of individuals while protecting public needs and fully recognizing current limitations of programs and funding.

Also involved in phase II will be the Interagency Wetlands Committee, which consists of representatives from state government agencies that deal with wetlands-related issues. This committee reports to a group recently formed by Governor Edgar known as the Natural Resources Coordinating Council. The council is officially responsible for developing comprehensive recommendations for wetland conservation.

Sharon Baum and Tony Shaffer, Center for Wildlife Ecology

Hunt for Biological Control of Gypsy Moths

Predators, parasites, and pathogens have been used successfully to control insect pests for more than 100 years. The major advantage of biological control agents over pesticides is that the biological agents are more specific to the pests, reducing adverse effects on humans and other animal species and on the environment.

It is important to assure the safety of nontarget organisms when evaluating insect pathogens as potential biological control agents. Identifying species that will be susceptible to a specific pathogen is difficult, however, because many pathogens have a broad host range when tested in a laboratory. It is also difficult in a laboratory situation to evaluate factors such as the type and amount of exposure to pathogens encountered by hosts in nature.

Biological control agents are more specific to pests than are pesticides.

Another consideration is the nature of susceptibility of nontarget species to a pathogen. Initial multiplication of a pathogen in the tissues of a nontarget host does not necessarily mean that infectious forms will be produced and that transmission to another insect of the same species will occur. The development of disease varies with the pathogen species, the host species, and often with the dose of infective forms.

Studies at the Natural History Survey suggest that there is a continuum of results when nontarget species are exposed to potential pathogens. This continuum can be divided into four basic categories: (1) the nontarget species is not affected by the pathogen, (2) the nontarget species is killed by initial contact with the pathogen, but the pathogen does not develop in the tissues, (3) the pathogen produces light infections and/or atypical infections, or (4) the nontarget host is heavily infected and produces infectious forms. Only in the last category is the pathogen likely to be transmitted from an infected nontarget host to other individuals of the same species.

The gypsy moth female, which is flightless, mates and lays eggs on the trunk of the tree where she fed as a caterpiller.

Among the pathogens that have been evaluated for potential use in controlling the European gypsy moth, a serious forest tree defoliator now invading Illinois, are three species of microsporidia (microscopic, parasitic organisms). To see whether these microsporidia will seriously affect insects other than the gypsy moth, Survey researchers have assessed their effects on a number of native forest moth species and on one butterfly.

Microsporidium portugal was fed to 22 species of Lepidoptera (moths and butterflies). The only host species that became heavily infected was the gypsy moth. Although many other species showed initial susceptibility to the pathogen, they did not produce enough infective spores to transmit the disease. *Vairimorpha lymantria* was fed to 16 lepidopteran species. Three of them, including the gypsy moth, became heavily infected, but the other 13 showed responses similar to those seen in *M. portugal* infections. By contrast, *Endo-*

reticulatis schubergi infected eight of 14 species. This microsporidium is a generalist, infecting a broad range of hosts; indeed, it is found naturally in some North American moth species.

The studies validated the hypothesis that initial infection may not lead to complete development of a microsporidium in a nontarget host. Microsporidia that develop in an altered manner in a nontarget host technically infect these hosts, but the pathogen will probably not be transmitted in nature. These results may be useful for estimating the ecological host specificity (host specificity in natural situations) of microsporidian pathogens. If viable infections cannot be produced in the laboratory, where conditions are ideal for exposure to spores, then it is unlikely that transmissible infections will occur in nontarget hosts under natural conditions, where other environmental factors complicate survival and transmission.

Although *Endoreticulatis schubergi* may be unsuitable for the biological control of gypsy moths because it may adapt to nontarget hosts, *Vairimorpha lymantria* and particularly *Microsporidium portugal* appear to be quite host-specific. These results are very encouraging in terms of using the latter two organisms to control gypsy moth populations without adversely affecting other species.

Leellen Solter and Joseph Maddox, Center for Economic Entomology

The copper underwing was resistant to infection by two microsporidia that infected the gypsy moth.

More Muskellunge for Illinois Anglers

The muskellunge is one of the most popular sport fishes in the Midwest. Unfortunately, this elusive and highly valued fish has been unable to reproduce successfully in Illinois. When adult females scatter their eggs in shallow waters in Illinois' reservoirs, the eggs sink into the silty substrate, starving them of oxygen.

To maintain muskellunge populations in Illinois, the Department of Conservation has had to implement a huge stocking program. Each year, thousands of muskellunge are raised in hatcheries and stocked in lakes around the state. Many of these fish, however, are eaten by largemouth bass, or they simply die. Natural History Survey researchers have been studying methods to improve hatchery techniques so that more muskellunge survive in the wild.

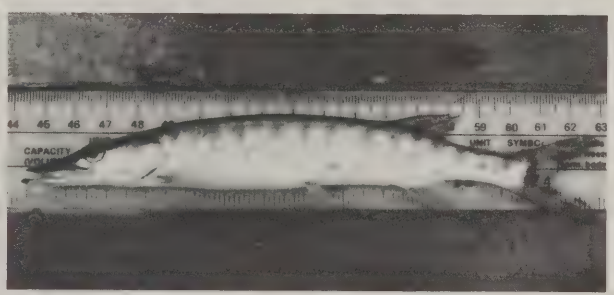
One facet of hatchery operations that has been evaluated is the type of food given to the muskellunge. Feeding live minnows to young muskellunge is traditional practice, but minnows can be very costly, and they can introduce disease. Consequently, hatcheries in some states, including Illinois, have tried feeding muskellunge pelleted food (much like tropical fish food), which is relatively inexpensive and does not transmit disease. Survey researchers found in experimental stockings, however, that muskellunge raised on minnows are more likely to survive in the wild than those fed pellets. Studies are currently being conducted to determine why minnow feeding is advantageous.

Another important issue is how long to keep muskellunge in the hatchery. The longer a fish stays in the hatchery, the bigger it gets and the more likely it will survive in the wild (too big for most bass to eat), but the more it costs. The traditional stocking size for muskellunge is 4 inches, but years of data from many Midwestern states have shown that muskellunge this size are consistently eaten by largemouth bass.

When Survey staff compared the survival of 4-, 8- and 10-inch muskellunge in experimental stockings, they found that the largest individuals had the highest survival. When survival is taken into consideration, 10 inches is the most cost-effective size for stocking.

Survey researchers are also trying to determine whether a particular genetic strain of muskellunge is best suited for Illinois. Hatcheries in Illinois acquire eggs from other states (principally Minnesota, New York, Ohio, and Wisconsin), and muskellunge from each state may be genetically distinct. An ongoing project is monitoring the survival and growth of various strains in laboratory aquariums and experimental ponds.

Other ongoing studies are comparing the results of raising



Muskellunge stocking was most cost-effective when the fish were 10 inches long when released.

Muskellunge

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muskellunge in large outdoor ponds versus growing them in indoor troughs. Preliminary data from tests in experimental ponds and reservoirs seem to indicate that fish raised in outdoor ponds are better suited for the wild; however, more research is needed.

A final set of Survey studies is trying to make muskellunge more fearful of bass. Because hatchery-raised fish spend the first four to six months of their life in an artificial environment, free of bass and other predators, they apparently are ignorant of the threat posed by the larger fish. In fact, in laboratory experiments, Survey researchers have found that hatchery-raised muskellunge will actually swim up to a hungry bass, not realizing the imminent danger.

In the western United States, researchers have found that exposing hatchery trout or salmon to predatory fish greatly increases survival in the wild. The rationale is simple: let hatchery fish see a predator eat some of their own, and they will be more apt to avoid predators when stocked. This summer, Survey investigators will be conducting experiments to see whether muskellunge can similarly be conditioned to avoid largemouth bass. Stay tuned.

Doug Wojcieszak, David Wahl, David Clapp, and Thomas Szendrey, Center for Aquatic Ecology

Predicting Rootworm Injury to Corn

Western and northern corn rootworms are the most serious insect pests of nonrotated corn (corn planted following corn) in the Midwest. Adult female rootworm beetles lay the vast majority of their eggs in the soil of cornfields during August and early September, and the eggs lie dormant until hatching in the spring. Larvae of both species feed almost exclusively on corn roots and can cause extensive root injury and yield loss.

In 1990, Illinois farmers devoted 2.8 million acres to nonrotated corn and treated 88% of those acres with a soil insecticide aimed mainly at rootworms.

Because rootworm larvae cannot survive on roots of crops such as soybeans, alfalfa, or wheat, crop rotation is recommended to manage these pests. In fields where corn is grown year after year, soil insecticides are typically applied to protect root systems from rootworm feeding. In Illinois alone, farmers devoted 2.8 million acres to nonrotated corn in 1990, and 88% of these acres (2.5 million acres) were treated with a soil insecticide aimed primarily at corn rootworms.

Ever since rootworms became pests of corn, there has been a need for a reliable method of estimating population densities of rootworm adults in a cornfield so that growers and crop consultants can predict which fields might benefit from a soil insecticide the following season. Both visual counts of rootworm beetles on corn plants and counts of beetles captured on sticky traps have been used to provide these estimates. Because the density and percentage of female rootworms is generally higher in first-year cornfields than in nonrotated fields, researchers have concluded that different economic thresholds (the population density of a pest above which economic loss can occur) should be used for the two cropping systems.

Researchers in Iowa found that sticky traps and the visual plant count method were equally effective in predicting subsequent rootworm larval injury, but neither method could account for more than 27% of the variability in root injury. Consequently, a better sampling method is needed, perhaps one that also takes into account sex ratios. Beetles captured on sticky traps cannot be sexed readily because the sticky material gets all over the insects.

In the early 1980s, Natural History Survey researchers John Shaw and Bill Luckmann developed a trap that was small and easily handled, inexpensive, and without sticky material. The trap used a perforated plastic medicine vial containing an acetate strip coated with insecticide and powdered squash with high levels of cucurbitacins. Cucurbitacins are a group of compounds found in bitter squash, cucumber, and melons that make rootworm beetles feed compulsively. Beetles randomly enter the trap and feed on the powdered squash, ingesting a lethal dose of the insecticide. Because the beetles are free of sticky material, they can be easily sexed under a microscope.

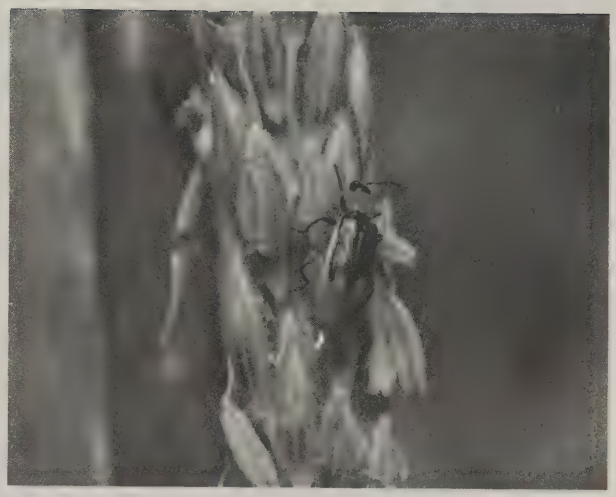
To determine the usefulness of the cucurbitacin vial trap in forecasting subsequent root injury, female and total trap catch data from earlier Illinois studies were analyzed along with data recently collected from additional fields. Traps were attached to corn plants at ear height, and the beetles were collected and sexed for various intervals throughout August.

Significantly more variability in root injury was explained by using female capture data than by using

data for both sexes for all sampling intervals except the last week of August. For this period, neither female nor total capture data explained a significant amount of the variability in rootworm injury. The only case in which combined male and female capture data explained a significant amount of variability was for the third week of August. Even for this time interval, however, female trap data explained nearly twice as much variability as did total beetle capture. The best sampling methods for predicting subsequent root injury were based on average female capture for the entire month of August, average female capture for the last three weeks in August, and average female capture for the third week in August. These methods accounted for 73–82% of the variability in root injury, about two- to threefold better than estimates based on total beetle capture.

Current adult corn rootworm sampling methods do not directly take into consideration the number of females. A sampling program with an economic threshold based on female counts during the egg-laying period should more precisely forecast which fields may develop damaging infestations of rootworm larvae the next year. Fields identified as high risk could be planted with a nonhost crop or treated with a soil insecticide if planted back to corn. Low-risk fields would not need to be treated. This pest management strategy is preferable to the widely practiced approach of prophylactic reliance on soil insecticides.

The cucurbitacin vial trap may not be useful for producers and consultants who lack the will, time, or knowledge to identify the sex of trapped beetles. Nonetheless, this study shows that the number of adult corn rootworm females in a field is a better indicator of subsequent root damage by larvae than is the total number of adult rootworms, and it underscores the need to develop a trap that captures only females. The results also indicate that the sampling period need not be a long time. One to four weeks during August should be sufficient for corn planted in May.



Western corn rootworm beetle.

Eli Levine and Michael E. Gray, Center for Economic Entomology

Lessons from the Prairie

Nearly all of the 22 million acres of prairie originally found in Illinois has long been overtaken by corn and soybeans. Nonetheless, remnants of prairie can still be found throughout the state along abandoned railroads, in pioneer cemeteries, and in numerous protected, restored sites totaling about 2,300 acres.

Patches of prairie can also be found at several elementary schools in Champaign, Illinois. Through the efforts of a few dedicated teachers and with the assistance of Natural History Survey staff, these small stands of prairie plants are being used to teach not only science but also art, writing, reading, math, history, and social studies.

Prairie gardens have so far been established at five schools. The prairie garden at Dr. Howard School was started several years ago by teacher Mary Petry, with seeds and plants donated by David Monk, a local prairie advocate. This year Survey staff will instruct teachers and students in better management practices and assist in the incorporation of missing native species.

The prairie garden at Robeson School was planted by Dorothy Fritchie and her third-grade students, with plants provided by the Survey. At South Side School, a native butterfly garden was started through the efforts of teachers Diane Elliot-Weaver, Marian McPhee, and Evon Cataneo, with design and planting assistance provided by Michael Jeffords, Susan Post, and Ruth Green of the Survey. Plant material for this garden was provided by a local business, Prairie Gardens, as well as the Survey.

Prairie butterfly garden at South Side School in Champaign. The garden consists of native perennial plants that attract butterflies.

A prairie garden was put in at Washington School this past fall by the third-grade students of Carol Miller and Scott Davis, with assistance from Survey staff mem-

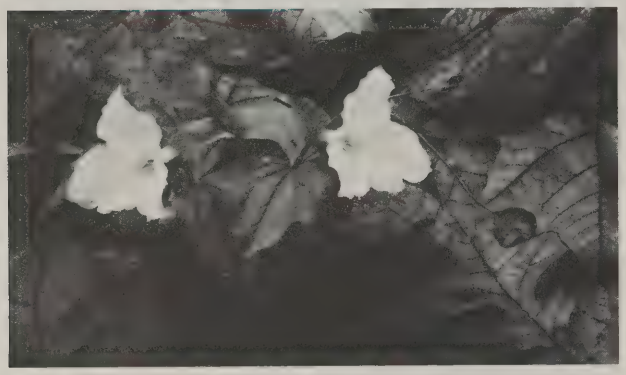
(Continued on back page)

Species Spotlight

Great White Trillium

It is finally spring! Winter's gray-brown, threadbare blanket of leaves on the forest floor is rapidly being replaced by an explosion of color. Each day brings new flower species—such as bloodroot, spring beauty, trout lily, and dutchmen's breeches—unfurling their leaves toward the sun in the race for sunlight before the trees leaf out.

Perhaps the most elegant of the woodland bloomers are the trilliums. Illinois has nine species of trilliums, whose flower parts are arranged in groups of three: three petals, three sepals, and three leaves. A common name for the trilliums is wake robin because they begin to flower after the robins have migrated north. Trilliums in full bloom are an indisputable sign that spring has arrived!



The great white trillium, with blossoms reaching 2 inches across, is the largest of the trilliums found in Illinois.

Illinoisans lucky enough to find an undisturbed woods may be rewarded with the gleam of the large white blossoms of the great white trillium, *Trillium grandiflorum*, the largest of the Illinois trilliums. Great whites occur from the Appalachian Mountains north through New England and eastern Canada. In Illinois, this species is found scattered in the northern half of the state, with one site in Jackson County in the south. The waxy white flower, with blossoms reaching 2 inches across, changes color as it grows older, going from snowy white, through pink, to deep purple-pink before the petals wither.

Because trilliums do not occur in Europe, they were new to the early colonists in North America. The great white trillium was one of the first plants to be sent from America to England for cultivation in English gardens.

A single, smooth, erect stem arises from an underground perennial bulb. Toward the top of the stem is a whorl of three leaves with net veining and smooth margins. A single showy flower with three petals tops the stem. When the petals wither and die, they soon are replaced by light green fruit. As the fruit matures, pressure splits the capsule open along one side, and the stalk bends down close to the ground. Sticky seeds, each with a light-colored crest of material called a strophiole, fall out of the mature fruit in clusters. Ants are attracted to this crest and carry it along with the seeds to their nests, where they eat the oil-filled strophiole and discard the seeds. Thus, the ants "plant" the seeds of the next generation of trilliums. Growth is usually slow, and it may take six years to produce the first flower.

Through photosynthesis, the leaves manufacture food to be stored in the rootstalk for the next spring's growth. If the leaves are continually picked, the plant will die. Trillium populations are prone to destruction by overpicking or attempted tranplanting by humans.

Browsing by deer, whose numbers are rising dramatically in Illinois, poses a new threat to great white trilliums. By using the great white trillium and other indicator species, park and preserve managers may be able to monitor deer browsing intensity and perhaps regulate deer numbers before one of Illinois' most showy spring forbs becomes extirpated.

Teacher's Guide to "The Naturalist's Apprentice" (facing page)

OBJECTIVE

to acquaint students with types of symmetry found in animals

SKILLS/PROCESSES

deduction, visual discrimination, comparison, simple geometry

VOCABULARY

asymmetry, symmetry, radial, spherical, bilateral, locomotion, sessile, plane

MATERIALS

multiple copies of **Animal Geometry** (facing page)

COMMENTS

Like the trilliums discussed in "Species Spotlight," animals also have definite geometric forms, mainly due to differences in symmetry. Simply defined, symmetry is the arrangement of parts of the organism relative to planes and straight lines. Animals can first be classified as either asymmetrical (examples are sponges or amoebae) or symmetrical. Symmetrical animals may be of three types. Radially symmetrical animals radiate out from a central axis; they are usually sessile animals that gather food from all directions. Hydras and jellyfish are examples. Spherical animals are symmetrical around a central point and may look like a ball. Locomotion for such animals is difficult, and many are free-floating. Bilaterally symmetrical animals, including humans, have similar right and left halves. The front end usually has a collection of nervous tissues contained in a head.

PROCEDURE

1. In class, discuss the different types of symmetry.

2. Distribute copies of **Animal Geometry** to the class and have students complete the activity. *Answers: radial–A, 6, 7; spherical–D, 3, 4; bilateral–C, 1, 8; asymmetry–B, 2, 5.*

3. Have each student bring items from home that illustrate the various types of symmetry. In addition, have them research and find pictures of animals (other than those found in this exercise) that have the various types of symmetry.

Animals have definite forms, mostly because of different types of symmetry. Items shown below at the left share the same type of symmetry with animals shown on the right. Determine the type of symmetry for each item and animal and record your answers on the blanks provided.

Radial symmetry

item ___

animals ___ , ___

Bilateral symmetry

item ___

animals ___ , ___

Spherical symmetry

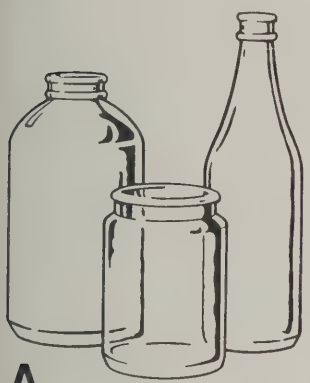
item ___

animals ___ , ___

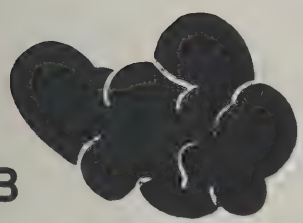
Asymmetry

item ___

animals ___ , ___



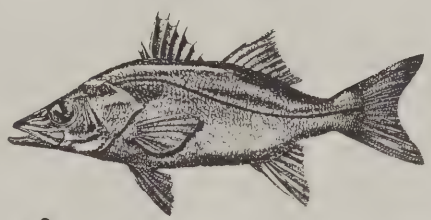
A



B

C

D



1

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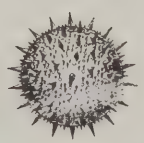

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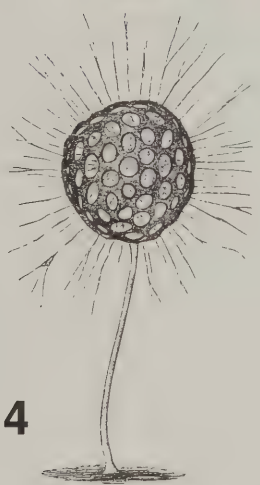

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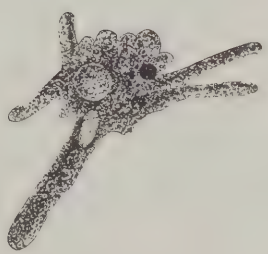

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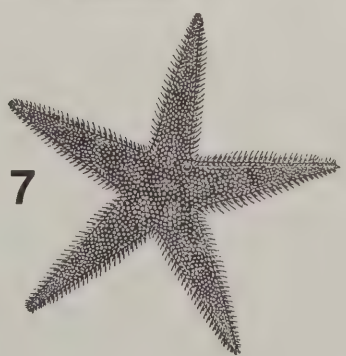

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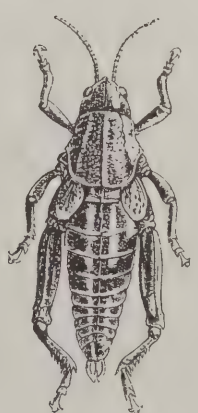

8

"The Naturalist's Apprentice" presents educational activities for middle school students. Teachers are invited to photocopy this page for classroom use.

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Prairies

continued from page 5

bers Ruth Green, Jeff Olson, and Alicia Nugteren. A prairie garden is likewise being started this spring at Bottenfield School.

Two special science curriculum units that can use the prairie patches as instructional tools were developed by a group of Champaign teachers with assistance from Michael Jeffords, the Survey's educational liaison officer. Second graders study a unit on butterflies and moths. They collect larvae of these insects and observe the different developmental stages. Insect anatomy, feeding habits, life cycles, and insect and plant relationships are among the topics studied.

Small stands of prairie plants at Champaign elementary schools are being used to teach not only science but also art, writing, reading, math, history, and social studies.

Third graders study a unit on prairies. By observing prairie plants, they learn the basic principles of plant growth and development, as well as how to identify various prairie species. The students also learn about the interaction of prairie plants and animals to form a unique ecosystem, the importance of prairie fires to Native Americans and to the prairie itself, and the role of the prairie in creating the fertile topsoil that has made Illinois an agricultural giant.

Geology is introduced when the students learn about the glaciers that passed over the prairie region, causing the uniform flatness so different from the topography of northwestern or southern Illinois. Math skills are used to make root and shoot comparisons and to measure plant growth and root development in a variety of soil types.

Educators may also use the study of prairies to help teach subjects other than science and math. For example, third graders may be required to read *The Little House on the Prairie* by Laura Ingalls Wilder or *Sarah Plain and Tall* by Patricia MacLachlan. The students learn what life was like for a pioneer family living on the prairie in Champaign County. How did the pioneers navigate across the prairie? How did they protect themselves from storms or prairie fires? What did they eat? Where did they live? Often the students put on dramas depicting prairie life, and some turn their classrooms into prairie museums that other classes visit to learn about prairie life. These exercises incorporate reading, creative thought, and writing, as well as lessons in social studies and history. Some Champaign educators say that one of the best aspects of teaching about the prairie in Illinois is that it provides students a tangible link to the state's past.

Many teachers have also used prairie patches to help teach art. Through careful examination and observation, the students have captured on paper the vast array of colors and forms that native prairie plants exhibit.

In addition to helping schools set up their own native prairie gardens, the Natural History Survey maintains its own 2-acre prairie, which can be toured by school groups during the fall. Students are able to experience for a moment what the pioneers felt as they passed through prairie grass over 10 feet tall in every direction as far as the eye could see.

For more information on using native prairie plants in an educational program or on touring the Survey's prairie, please contact Ruth Green (217-333-7091) or Michael Jeffords (217-333-5986).

Ruth Green, Center for Biodiversity

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INSIDE

A Biological Control for Purple Loosestrife?

A tiny aphid may help to save Illinois wetlands from a noxious weed.

The perennial exotic weed purple loosestrife (*Lythrum salicaria*) is degrading many wetlands throughout the temperate regions of North America. A large plant, it reaches over two meters in height. Its multiple stems are tipped with elongate spikes of purple flowers from July to September. Estimates suggest that a single mature plant can produce more than 2.5 million seeds a year.

Of European origin, purple loosestrife is now established in hundreds if not thousands of acres of Illinois wetlands. Considerable effort has been expended by the Department of Conservation to protect high-quality wetlands from invasion by this species, but control is difficult because specific herbicides or easy cultural control methods are not available. Biological control is now being considered as perhaps the only way to limit the distribution of this noxious weed.

Recent research at the Illinois Natural History Survey has explored the impact on purple loosestrife of large populations of the aphid *Myzus lythri*. These aphids overwinter as eggs on *Prunus mahaleb*, a wild cherry of European origin that grows along roadsides and forest edges. In spring the eggs hatch and three generations of aphids are produced on the cherry tree before winged aphids leave it in search of purple loosestrife on which the summer generations will live. This aphid, like its hosts, is of European origin and has been in North America for over 50 years.

Response of purple loosestrife seedlings eleven weeks after inoculation with five aphids per plant. Control plants on the left were free of aphids.

Experiments were carried out in the greenhouse using two-year-old loosestrife plants and four-month-old seedlings. Each of the plants was inoculated with five aphids and left for eight weeks along with non-inoculated plants. By the end of that time, the inoculated plants were literally covered from top to bottom with aphids. At the end of the experiment, all plants were removed from the pots, their roots carefully washed, and the plants then dried and weighed. The inoculated plants had significantly smaller roots and shoots. In addition, none had bloomed, some showed premature leaf drop, and others were severely stunted. The control plants had large, healthy leaves and some had flowered. The four-month-old loosestrife seedlings were inoculated with two or five aphids. After eleven weeks, approximately half of the seedlings had died or were dying. No difference was noted between seedlings inoculated with two or five aphids, and a significant difference was found between experimental and non-inoculated control seedlings.

These experiments show that the aphid *Myzus lythri* has the ability to influence the growth and flowering of purple loosestrife. Since this aphid is already found in this country, why has it not been working as a natural control? The answer appears to be found in its complex life cycle. It needs *Prunus mahaleb* and plants in the genera *Lythrum* or

Loosestrife

continued from page 1

Epilobium to complete its life cycle. *Prunus mahaleb*, however, is not commonly planted in North America, and the aphid population is limited by the scarcity of its wintering host. Another factor is the three-generation delay in the spring before winged aphids leave the host tree. As a consequence of this delay, their arrival on purple loosestrife does not occur until mid-June in Illinois. By this time, purple loosestrife can be quite large and will reach flowering stage before the aphid population reaches damaging levels. The need for migration is a related factor. Because aphids are feeble fliers and are carried by prevailing winds, significant losses to the population can occur during migration.

In spite of the lack of host trees, the late flight date, and the hazards of migration, *Myzus lythri* could be used as a biological control in the field. *Prunus mahaleb* could be planted near large stands of purple loosestrife so that hosts would be available and the migration distance limited. Aphids could also be mass reared during the winter months for release in April when purple loosestrife begins to grow. This schedule would give the aphid a head start of nearly two months on its natural cycle and allow the population to build before purple loosestrife begins to flower. Researchers at the Survey plan to test both of these schemes during the coming years to learn if this aphid can help to limit the spread of the noxious purple loosestrife.

David J. Voegtlin, Center for Biodiversity

Guide for Wetland Restoration and Creation

In the past, wetlands, such as marshes, wet prairies, floodplain forests, and swamps, were regarded as waste places with little value. Often they were regarded as breeding grounds for pestilence and disease, and government programs encouraged landowners to drain these areas. Only about 10% (918,000 acres) of the approximately 9.4 million acres of wetlands that existed in Illinois before European settlement remain today.

As awareness of the economic, environmental, and social values of wetlands has increased, efforts have turned toward protecting them. To that end, Illinois adopted the Interagency Wetlands Policy Act in 1989. Its short-term goal is to allow no overall net loss of existing wetland acres; a longer-term goal is to increase wetland acreage. This Act directs state agencies to avoid impacts to wetlands when possible or to minimize them. Although the preservation of existing wetlands is certainly the most desirable option, losses do occur. The Illinois Wetlands Mitigation Policy, therefore, requires that where adverse impacts are unavoidable, the wetland loss must be compensated for through the development and implementation of a Wetland Compensation Plan approved by the Illinois Department of Conservation.

Only about 10% of the original Illinois wetlands remain, but restoration becomes more feasible as our understanding of wetland form and function improves.

Wetland restoration and creation are two means by which compensation may be accomplished. Restoration refers to the reconstruction of a wetland where a wetland community previously existed. At potential restoration sites, one or more of the original components (wetland hydrology, hydric soils, or wetland vegetation) remains. Alternatively, wetland creation requires the construction of a wetland in a location where one never occurred.

The art and science of wetland restoration and creation that emphasizes natural wetland structure and function is relatively new and the technology is incomplete. As a result, attempts to replicate natural form and function have generally been unsuccessful. In an effort to counter this trend, members of the Wetland and Preliminary Studies Group are developing a guide for the restoration and creation of wetlands. This project, supported by the Illinois Department of Conservation, is being carried out cooperatively by personnel from the Center for Biodiversity at the Illinois Natural History Survey, the Illinois State Geological Survey, and the Illinois Department of Transportation.

The *Illinois Restoration and Creation Guide* has several well-defined and unique objectives. The first is to improve the overall quality and success of wetland restoration and creation projects. The document will provide information for making informed decisions during each stage of the restoration or creation process. The second is to reduce costs of mitigation. The guide will outline procedures to reduce the likelihood of problems and the need to redesign the reconstruction effort after it is underway. A third objective is to help agencies comply with the Interagency Wetlands Policy Act. The guide is being written primarily for use by state agencies and will be

appropriate in both regulatory (such as to satisfy mitigation requirements) and nonregulatory contexts. A final objective is to reduce the number of staff and the amount of funding necessary to implement the Act. Because essential information will be found in a single document, orderly procedures can be followed and false starts and revised designs avoided.

The guide incorporates technical information from various sources as well as the experience of the authors and will assist practitioners with backgrounds in biology, civil engineering, and landscape architecture. However, the best restoration and creation efforts will probably be accomplished through interdisciplinary teams that include specialists in hydrology, pedology, botany, and wildlife biology.

The guide is based on the assumption that wetlands will be restored or created in order to perform particular functions, such as floodflow alteration, sediment stabilization, nutrient removal and transformation, and increased biological diversity or abundance. The working draft comprises six chapters that are correlated to stages in the wetland restoration or creation process: planning, assessment, design, construction, monitoring, and management. In each chapter, procedures are emphasized, tasks clarified, and the techniques required to perform each task outlined. Depending on particular site conditions and the circumstances of the project, tasks can be conducted according to one of two levels of effort. The design of the guide will enable individual chapters to be updated as new methods and technology become available.

A draft of the *Illinois Wetland Restoration and Creation Guide* will be reviewed by Department of Conservation personnel and the Interagency Wetland Committee later this year. Publication is expected in 1995.

Alicia Nugteren Admiraal, Center for Wildlife Ecology

Badgers Persevere

Much of the animal life associated with the tallgrass prairie disappeared or declined greatly as the prairie was plowed for agriculture in the 1800s. The American badger (*Taxidea taxus*) is one prairie "relict" species that has persisted in the Midwest, although little is known about its historic or current status. In 1989 researchers at the Illinois Natural History Survey initiated a project to map badger distribution in Illinois and to learn how this species has survived in a much altered environment. The project is supported with Pittman-Robertson funds from the Division of Wildlife Resources at the Illinois Department of Conservation (IDOC) and the U.S. Fish and Wildlife Service.

Reports of badger sightings have been collected from the public, IDOC staff, Survey biologists, and Illinois Department of Transportation personnel (the latter encounter road-killed badgers). Despite the lack of prairielike habitat, badgers are presently distributed throughout the state. Before European settlement, badgers were probably found only in the northern two-thirds of the state; however, the clearing of forests for agriculture and strip mining altered the southern third of the state, creating open conditions more suitable for badgers.

This carnivorous species is ideally adapted to excavate and prey upon such small burrowing mammals as ground squirrels, pocket gophers, voles, and mice. As a result, badgers thrived in prairie. Currently, however, more than 65% of the land in Illinois is used for row crops, and smaller prey species such as house and deer mice are now the most common rodents in farm fields. Clearly, the prey base for badgers has decreased statewide since prairie days.

At a site in Mason County in west central Illinois, researchers are intensively studying badgers by fitting them with radio transmitters and tracking their movements. Tracking has proved more difficult than expected because individual badgers may travel more than two miles in a given night as they wander and hunt over the landscape. An adult female's home range varies from 6 to 10 square miles, and male ranges are even larger. Furthermore, there is little overlap of home ranges for badgers of the same sex, although male ranges extensively overlap those of females. In contrast, home ranges for badgers studied in Utah, Idaho, and Wyoming are typically 1 to 2 square miles. Thus, badger densities in Illinois appear sparse compared to those in western states.

Badgers have been found in all Illinois counties except four in the southern fourth of the state; their presence there is suspected but unconfirmed.

Badgers

continued from page 3

Unlike the unnatural cropped landscapes of Illinois, the landscapes of western states provide abundant seminatural rangeland suitable for badgers. This cover type often supports a large number of semicolonial prairie dogs and ground squirrels. In Illinois, habitats that mimic the vegetative structure of prairie grasslands provide more abundant and diverse prey for badgers than do row crops. As a result, badgers turn to cover types that are scarce—alfalfa, weedy fallow fields, and grassy cover established under the Conservation Reserve Program—and they rely on these cover types more frequently than would be predicted based on their availability. This tendency suggests that the larger home ranges observed in Illinois reflect a reduced prey base and a reduction in habitat quality.

The contemporary Illinois landscape does not allow for optimal survival and reproduction of badgers. Although 60–70% of adult females in Mason County produce young each year, the rate of survival by juveniles is low. Less than 40% of young badgers live long enough to leave their mothers. Even under the care of an adult female, juveniles are vulnerable to predation by coyotes and dogs. When immature badgers disperse from their mothers, they may travel more than 10 miles, thereby assuming the risks of crossing unfamiliar territory and many roads.

The persistence of badgers in Illinois despite dramatic changes in the landscape is testimony to the remarkable adaptability of the species. Ongoing research should reveal which, if any, prey species are of particular importance to badgers, whether or not linear habitats such as hedgerows and fencelines benefit badgers in intensively cropped landscapes, and whether the mortality rates of adult males and females differ.

Barbara Ver Steeg, Center for Wildlife Ecology, and Richard E. Warner, Department of Forestry, University of Illinois

Savannahs and Breeding Bird Communities

A serious problem faces managers and conservationists in Illinois: the welfare and sustainability of forests and wildlife. Oak-hickory forests throughout the Midwest are apparently not regenerating at historical (i.e., postglacial) levels, and oaks are gradually being replaced by shade-tolerant species, especially Sugar Maples (*Acer saccharum*). Much of the southern and central Midwest has been dominated by the oak-hickory forest-type for nearly 8,000 years, but a process that is underway may fundamentally change the structure of the remaining forests in Illinois and surrounding areas.

How does forest structure affect bird populations? Survey researchers hope to find some of the answers.

The ecological factors underlying this conversion are not fully understood, but disturbance and the lack of fire are certainly involved. As a result, the use of prescribed fire and the removal of maples are being considered to insure the perpetuation of oak-hickory forests. Juxtaposed against the problem of oak regeneration is a concern for forest wildlife and how the viability of those populations may be affected by fire and disturbance. This relationship is ambiguous for forest birds in Illinois. Many species may benefit from a closed canopy along with a well-developed layer of shrubs or saplings or both. Other birds may require more open, savannah-like conditions. Further, several species of neotropical migrants, some of which are decreasing in Illinois and throughout the Midwest, are potentially sensitive to prescribed burning and disturbance. Forest and wildlife managers obviously need baseline data if policy is to be based on a clear understanding of what fire will do to *all* components of the forest ecosystem.

The Center for Wildlife Ecology at the Illinois Natural History Survey has initiated a three-year study to evaluate the effects of prescribed burning and understory removal on bird populations in oak forests. The project is supported by The Nature Conservancy, the Illinois Department of Conservation (Division of Natural Heritage), the U.S. Fish and Wildlife Service, and the Peoria Park District. Major research sites are the Peoria Wilds Conservation Areas, which are owned primarily by the Peoria Park District. Birds within Singing Woods, a 953-acre forest tract, will be studied intensively. Plans are in place to remove maples and burn several areas within this tract and elsewhere within Peoria Wilds during 1994–1996. The goal is to convert closed-canopy forests to more open, savannah-like forests such as those that predominated locally in presettlement times and to evaluate the positive and negative effects of this conversion on a diverse set of birds. When possible, avian abundances and breeding success will be estimated within prospective burn units be-

fore and after conversion. During each of the three years of the study, similar data will also be collected for control areas located at a distance from the converted areas. Bird populations inevitably fluctuate among years, and controls are essential so that changes in environmental conditions (for example, drought) do not confound the effects of burning.

This sampling design will allow the study of species that may be directly affected, either positively or negatively, by the conversion practices. For example, Wood Thrushes (*Hylocichla mustelina*), Ovenbirds (*Seiurus aurocapillus*), Kentucky Warblers (*Oporornis formosus*), and Worm-eating Warblers (*Helmitheros vermivorus*) are ground- or shrub-nesting species that may require saplings or forest litter and may be negatively affected by burning. All of these species are neotropical migrants found within Peoria Wilds. Alternatively, Red-headed Woodpeckers (*Melanerpes erythrocephalus*), Indigo Buntings (*Passerina cyanea*), and Northern Orioles (*Icterus galbula*) favor more open woodland and may benefit from the conversion techniques. A concerted effort will be made to monitor the viability of populations of these species. The effects of burning on brood parasitism by Brown-headed Cowbirds (*Molothrus ater*) and on rates of nest predation will be of particular interest. Some data suggest that birds associated with savannah-like forests are less likely to be parasitized. Whether this tendency stems from the behavior of the birds themselves or from some property of the habitat is unknown. Finally, the foraging behavior of selected species will be compared within and away from burn units. Data such as the number of foraging maneuvers or prey captured per unit of time will provide insight into how burning affects the availability of food resources needed during the breeding season.

The relatively open understory and canopy of this Illinois oak forest can be maintained by prescribed burning.

Jeffrey D. Brawn, Center for Wildlife Ecology

More Walleye for Illinois Anglers

Walleye (*Stizostedion vitreum*) is a popular sport fish in Illinois and throughout the Midwest. Unfortunately, the supply for the state's anglers does not always meet the demand. Heavy fishing pressure and limited natural reproduction combine to make it difficult for state fishery managers to maintain adequate walleye populations. In an attempt to insure a continued supply of walleye for anglers, the Illinois Department of Conservation (IDOC) has stocked large numbers of hatchery-reared walleye in Illinois reservoirs and impoundments (artificial lakes). Each year, the IDOC places millions of walleye fry (less than 1-inch long) and thousands of fingerlings (2–4 inches long) in lakes throughout the state; however, this stocking program, like those in other midwestern states, has met with mixed success.

The Illinois Natural History Survey, in cooperation with Southern Illinois University, is attempting to improve the success of walleye stocking programs by trying to find out what happens to walleye when they are stocked. A combination of field, pond, and laboratory tests are being implemented to carry out this research.

Field efforts currently evaluate walleye stocking in fifteen lakes throughout Illinois and include determination of mortality from stocking stress/shock, mortality due to predation, and survival during the first year after stocking.

Mortality resulting from handling walleye at stocking time and stocking at an inappropriate lake temperature is easily determined. Experiments show that greater than 50% of the walleye can die from shock if the lake water is too warm or too cold during stocking. If young walleye overcome the initial stress, they are then vulnerable to predators until they grow large enough not to be eaten. Predator mortality can result in the loss of an additional 10–20% of stocked walleye. Due to these and a variety of other factors, greater than 90% of stocked walleye probably do not survive past their first year of life.

A walleye photographed in a laboratory aquarium.

(Continued on back page)

Species Spotlight

Great Blue Heron

As the early morning mist evaporated, the call of a barred owl echoing off the cypress trees gave way to the raucous squawks and screams of a Great Blue Heron rookery. Our presence was acknowledged with the swish of a small missile—a regurgitated fish landing at our feet—a rather nice "welcome gift." It is best to observe a heron rookery from at least spitting distance.

The Great Blue Heron, the largest of the Illinois herons, stands four feet tall with a wingspan of six feet.

The rookery of a Great Blue Heron resembles a treetop apartment building of nests. Other water birds, such as egrets and cormorants, often share a rookery—the more noise, the better. In Illinois, rookeries are usually located within extensive tracts of bottomland forest. The largest trees are generally chosen, and the nests are placed high in the branches. Nests are about four feet wide and a couple of feet deep—a jumble of sticks and twigs. A rookery is used through dozens of heron generations and may contain anywhere from 5 to 500 nests. The squawking of birds and the smell of excrement and decaying fish alert one to a rookery long before it can be seen. When agitated, nesting herons will whitewash intruders with excrement or regurgitate their last meal upon the unsuspecting visitor, the avian equivalent to pouring boiling oil over medieval city walls.

Great Blues occupy the rookery for almost three months. Each nest has three to seven bluish eggs, which are incubated for about a month. For six weeks, until the young birds can fly and find food on their own, the parents are responsible for their brood. Of the four to five that hatch, only two or three will survive; owls, vultures, and tree-climbing mammals take their toll, and some youngsters are pushed from the nest. Great Blues mature in 3 years and have a life span of about 20 years.

The Great Blue Heron is found exclusively in the Western Hemisphere and can be found as far west as the Galapagos and as far north as Greenland. In Illinois, it occurs primarily along major rivers but is also seen at marshes and lakes or anywhere near water. As the state's largest heron with a wingspan of six feet, it stands four feet tall on long stiltlike legs, weighs from five to eight pounds, and is blue gray in color with white about the neck. Its beak is like a strong, pointed spear and is longer then the rest of its head.

Great Blues feed anywhere there is food, including flooded meadows, fields, and sloughs during times of runoff. They are undiscriminating carnivores and will eat almost anything that fits in their gullets—including fish, snakes, and frogs as well as field mice, small muskrats, and even lowland nestling birds. Everything is swallowed head first, which makes it easier on the gullet when regurgitating to feed the young. Great Blues have more than 30 different feeding movements, and these range from walking slowly to wing flicking to foot stirring. Like an experienced trout fisherman who knows what lures and line to use when fishing a particular area, the heron employs a variety of strategies when foraging.

Take time to enjoy this scene, for few sights are more primeval and more beautiful than the eerie silhouette of a fishing heron in the misty early morning light of an Illinois wetland.

Deformities in Aquatic Macroinvertebrates

Discharges from domestic and industrial wastewater treatment facilities contribute varying levels of pollutants to aquatic systems. These pollutants include sewage, nutrients, animal food processing wastes, paper and pulp mill byproducts, a variety of petroleum-based effluents, and other toxic chemicals. These discharges often result in macroinvertebrate assemblages below the outflow that are characteristic of specific effluents. Although numerous methodologies have been developed to characterize water quality of streams, particularly the influence of organic loading on aquatic communities located downstream from the discharge, these methodologies have contributed little to documenting the influence of toxic chemicals on aquatic macroinvertebrates.

One way in which effects of toxic contaminants on aquatic fauna can be demonstrated is through analysis of morphological deformities. Past studies have demonstrated increases in deformity frequencies in aquatic macroinvertebrates that have been collected from substrates with elevated levels of metals, polychlorinated biphenyls, pesticides, radioactive materials, and other carcinogens. Monitoring a polluted lake in Sweden during the 1970s, for example, revealed a highly significant correlation between incidence of deformities in morphological structures of aquatic worms and high mercury concentrations in sediments. Deformed macroinvertebrates have been collected from many sites in North America that contain sediments contaminated with effluent from pulp and paper mills, metals, and oil residues. Experimental work in which the conductivity levels in water were changed also resulted in morphological deformities in selected macroinvertebrates. A recent study in North Carolina focused on morphological deformities in midge larvae (Diptera: Chironomidae) and found that organic loading of streams resulted in nonsignificant increases in number and extent of deformities but that toxic conditions resulted in significant increases in both. Researchers then developed an index of toxicity that gives greater weight to more severe deformities of morphological characters observed in the midge larvae.

The application of this methodology to segmented worms (Oligochaeta), a group represented by several species commonly found in clean as well as polluted systems, is under consideration at the Survey. If this methodology shows merit, it will provide researchers with an additional way to monitor water quality, particularly in aquatic systems where high organic loading often masks the toxic effects of discharge on macroinvertebrate populations.

Mark J. Wetzel, Center for Biodiversity

The scanning electron micrograph on the left shows a dorsal chaetal bundle of deformed hairs of a species of Limnodrilus *(Annelida: Oligochaeta: Tubificidae) at a magnification of 3500X. The micrograph on the right shows a bundle of normal hairs (magnification 1650X).*

Two-minute Naturalist

Each Friday afternoon the University of Illinois presents *Afternoon Magazine* on its FM radio station (90.9). As a part of that program, the Natural History Survey is featured in a two-minute slot: "Illinois Naturalist." Survey staff generate the content, which focuses on current topics of biological interest to Illinoisans. Susan Post, Charlie Helm, and Mark Schwartz serve as narrators, and Michael Jeffords and Mark coordinate the effort.

Tune in at 2:40 on Friday afternoons and you and your family (or classroom) will discover much that is fascinating about your home state. Did you know that bald eagles are on the rebound in Illinois after near extinction in the 1960s? The winter population has doubled in four years to a high of just over 2000. And what determines an early or late migration for Canada geese? They probably won't be seen in Illinois until 10 to 20 inches of snow cover the Wisconsin landscape. The lack of open land for foraging and open water, not the cold per se, triggers the migration. And what about the central heating system of skunk cabbage? It's the earliest flowering plant in Illinois and manages this feat by using energy stored for months in its starchy tuberous roots. It generates enough heat to melt through leftover snow and to maintain summerlike temperatures inside the plant on subfreezing mornings.

"Illinois Naturalist" also suggests how you can follow up on enticing stories like those. Where do you go and when if you want an opportunity to view bald eagles in Illinois? How about finding bare sandstone ledges, remnants of the ancient Ozarks, for an autumn hike? Would you like to visit a maple sugar camp—not in Vermont but right here in Illinois? Turn to 90.9 on your FM dial each Friday at 2:40.

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Walleye

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Additional field sampling is directed at estimating the types of food walleye prefer and the availability of food sources in each lake. Walleye fry eat zooplankton (free-floating microscopic organisms); fingerlings eat insects and other fish. Experiments will determine what groups/types of zooplankton, insects, and fish are eaten by walleye relative to what is available to them in each lake. Survey researchers also hope to find out when walleye food is most abundant. With this information, stockings could be scheduled when the lakes have the most food for the fish. Improved growth and survival for walleye might result.

Results from field testing will be complemented and enhanced by pond and laboratory experiments. Tests in experimental ponds allow investigation under controlled conditions similar to those present in field tests. For example, numbers and species of larval fish, a potential food source for walleye fingerlings, can be manipulated in pond experiments to investigate the influence of larval fish density and species composition on walleye growth rates. Laboratory experiments are used to further investigate the mechanisms governing the relationships observed in pond and field experiments. Currently, laboratory tests are being used to determine how scarcity of food might influence the susceptibility of walleye to predation.

Data from field, pond, and laboratory tests can be combined to give researchers a better understanding of the factors influencing walleye survival and growth. Results of these studies will be used to make recommendations to fishery managers regarding the most appropriate sizes of walleye to stock, the best time of the year to stock them, and the lakes most suitable for them. Ultimately, this research should improve the success of walleye stocking programs in Illinois and throughout the Midwest.

David Clapp and David Wahl with Douglas Wojcieszak, Center for Aquatic Ecology

More than 90% of walleye stocked in Illinois reservoirs and impoundments probably do not survive their first year. Using a combination of field research and laboratory testing, Survey researchers look for answers.

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INSIDE

Biological Control of European Corn Borer

Tiny wasps encased in specially formulated capsules may help to control European corn borer

The European corn borer remains the most destructive above-ground insect pest of corn in Illinois, and yield losses are estimated to exceed $50 million annually. According to a December 1991 article in *Prairie Farmer*, an infestation in 1991 cost Illinois corn growers an average of $36 per acre—the third most severe infestation in Illinois. Only 1949 and 1989 had higher infestations.

As the name implies, European corn borers are not native to North America. In the early 1900s, corn borers began their westward movement. By 1939, they were reported for the first time in Lake County, Illinois. Within two years, serious infestations had developed in Kankakee County; by the mid-1940s, borers could be found in every county in the state. George C. Decker, John H. Bigger, and H. B. Petty, entomologists with the Illinois Natural History Survey and the University of Illinois, conducted initial fall surveys in 1942 and this annual activity persists to this day.

Early control efforts focused on encouraging growers to plant more tolerant corn hybrids, to clean plow fields, to shred stalks, and to adjust planting and harvest dates. With the justifiable concern over soil erosion, clean plowing has not been recommended for many years as a way to control European corn borers. With access to cheap and highly effective synthetic insecticides for over three decades, producers in Illinois have relied primarily upon this single tactic to control outbreaks of corn borers. In light of the escalating environmental concerns of the general public and the farming community, however, alternatives to conventional insecticides are increasingly sought. Currently, the Clinton administration has established a goal that calls for 75 percent of managed acres to be under an Integrated Pest Management plan by the year 2000. The clear intention of this objective is to reduce pesticide use.

Because of the current focus on reducing pesticide use in crop production systems, the biological control of insect pests is receiving renewed attention. The European corn borer has been the target, albeit an elusive target, of biologically based management programs for many years. The first attempt at classical biological control of the European corn borer in North America took place more than 70 years ago. Since then, nearly 40 foreign species have been imported (some accidentally) in an attempt to lower the natural density of this insect pest. In addition, nearly 100 native natural enemies of the European corn borer have been identified and these also aid in the suppression of borer densities. To date, only a very small minority of corn growers opt to use biologically based insecticides (those containing *Bacillus thuringiensis*), and most producers continue to rely on synthetic insecticides when economic densities of corn borers threaten. These insecticides are not highly selective, and natural enemies of corn borers and other insect pests are equally susceptible.

Corn is of central importance to the economic vitality of the state. Currently, 10.8 million acres of Illinois are planted in corn.

Five states (Illinois, Indiana, Iowa, Michigan, Nebraska) and Pioneer Hi-Bred, Inc., are currently in the second year of a three-year experiment designed to assess the commercial feasibility of using small parasitic wasps, *Trichogramma maidis*, to control European corn borers in seed production fields. These tiny wasps emerge from specially formulated capsules and kill corn borers by laying their eggs within the egg

Corn Borer

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masses of borers. Parasitized egg masses are unable to hatch and corn borer larvae fail to establish on the corn plant.

Since 1988, as a result of joint cooperation between the French government and a private company, growers in France and western Europe are able to purchase encapsulated *Trichogramma* wasps (Trichocaps). This unique formulation moderates harsh environmental effects and allows for greater ease in handling and applying parasitic wasps. Corn producers in France apply Trichocaps by hand on 90 percent of the fields; the other 10 percent are treated by airplanes.

The North American seed industry is interested in assessing the feasibility of this approach to European corn borer control because of the high value of the seed crop and the importance of minimizing the exposure of field workers to insecticides. Following the conclusion of the 1995 field season, researchers from each of the five cooperating states and Pioneer Hi-Bred, Inc., will report the results of the experiment and assess the potential usefulness of this biological approach to the management of European corn borers.

Michael E. Gray, Kevin L. Steffey, and John T. Shaw, Center for Economic Entomology

Zebra Mussels and Lake Michigan Snails

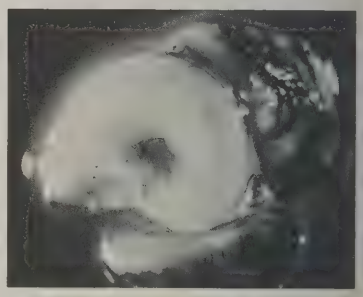
Populations of zebra mussels have been expanding recently in southwestern Lake Michigan. Divers off Chicago and its northern suburbs have noticed that coincident with this increase in zebra mussels is a decline in populations of native snails. The zebra mussels may be to blame. Just as the mussel will attach to a rocky substrate, it will also attach to the hard shells of freshwater snails.

A snail may carry a burden of up to 60 zebra mussels on its shell.

A snail less than an inch across was found to be carrying up to 60 zebra mussels on its shell. This burden could have several effects on the snail. In stormy conditions, the snail would be less streamlined and could be swept off the reef. Carrying around this large burden is also an energy drain. Snails with zebra mussels weighed less that snails without zebra mussels, by about 12 percent. Because the number of eggs that a snail can produce is proportional to its weight, this reduction in mass may translate into a significant reduction in population growth.

Not all snails, however, seem to be equally susceptible to fouling by zebra mussels. Large proportions of *Stagnicola* and *Goniobasis* tended to be fouled, but no *Lymnaea* had zebra mussels on them. Why are there differences? The texture of the shells is different. *Lymnaea* has a very smooth shell, making it difficult for juvenile mussels to get a foothold. In addition, there may be behavioral differences. Snails that crawl over each other can groom newly settled algae and mollusks off of their neighbors. A species may also have chemicals that act as repellents. Understanding why some species are susceptible to fouling and others are resistant may lead to the development of surfaces that are resistant to fouling. Shipholds and water intake pipes are particularly vulnerable to fouling by zebra mussels.

Because the ability of zebra mussels to foul snails differs among snail species, the mussels have the capacity to alter the composition of the snail fauna of Lake Michigan significantly. Some species may become locally extinct (none of the species is restricted to Lake Michigan) while others may persist, dominating the less diverse community that remains. Changes in the snail fauna could have other ramifications for the ecology of the Lake. Snails eat filamentous algae, and their disappearance from the Lake could lead to an increase in this kind of algae. Snails are also an important food for many fishes, including yellow perch, whitefish, burbot, suckers, drum, and sunfishes. In addition, snails are the intermediate hosts of a number of parasites that infect fishes and waterfowl and cause swimmer's itch in humans. Changes in the relative abundance of snails may affect the infection rates of these parasites and alter the patterns of infection.



Zebra mussels piggyback on a Lake Michigan snail.

We are beginning a project with Dianna Padilla of the University of Wisconsin that will investigate changes in the snail community due to zebra mussels, evaluate the mechanisms behind those changes, and explore why some snails appear to be more resistant to fouling than others.

Daniel W. Schneider and J. Ellen Marsden, Center for Aquatic Ecology

Survey Honors Its Founder, Stephen A. Forbes

The Survey recently celebrated the 150th anniversary of the birth of its founder, Stephen A. Forbes. Dr. Glen C. Sanderson, emeritus member of the Survey, former director of the Center for Wildlife Ecology, and recipient of the Aldo Leopold Award for distinguished service to wildlife conservation, delivered the birthday address. What follows are brief excerpts from that talk. In the interests of readability and with the permission of Dr. Sanderson, elisions are not shown.

Stephen Forbes was born May 29, 1844, to pioneer parents in a log cabin on Silver Creek, Stephenson County, northern Illinois. His father died when he was 10 and his brother Henry, 11 years older than Stephen, returned to the farm to care for the family. Stephen went to a local school until he was 14 and then was tutored at home by Henry. Henry managed to send Stephen to Beloit Academy for a brief period in 1860 to prepare him for college. Plans for college were cut short by lack of money, but Forbes taught himself to read French, Spanish, and Italian.

When the Civil War came, both Henry and Stephen supported the North, borrowed money to purchase horses, and joined Company B, 7th Illinois Cavalry. At 17 Stephen entered the army as a private; at 20 he was a captain.

Forbes attended Rush Medical College in Chicago after the war but left because he doubted that he was suited to the surgical aspects of the profession (especially surgery without anesthesia)—and a lack of money. For five years, ending in 1872, he raised strawberries near Carbondale, taught school, and studied and practiced medicine under a preceptor. In 1872 he began a career in biology, which was not to end until his death in 1930 in Urbana.

A partial list of his career titles includes Curator, Museum of the State Natural History Society; Director, State Laboratory of Natural History; State Entomologist; and Professor of Zoology and Entomology and Dean of the College of Science at the University of Illinois. Forbes was to become Chief of the State Natural History Survey and served from 1917 to 1930. Of special interest to us is his leadership in the establishment in 1894 of the Illinois Biological Station (the Survey's present Stephen A. Forbes Biological Station) on the Illinois River at Havana. The field station was the first in the world to make a continuing study of a river system. In these capacities he made major contributions to the scientific world but never lost sight of his responsibility to the welfare of the citizens of Illinois.

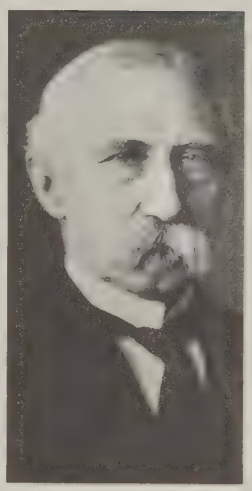
Forbes was a wildlife biologist, ornithologist, aquatic ecologist, entomologist, ichthyologist, and ecologist. His first report, published in 1870, was followed by more than 400 titles. Frank Smith, Professor of Zoology at the University of Illinois, wrote in 1926 that Forbes "did important work in botany and in a number of branches of zoology, he was far more than a specialist in any branch. He studied the birds and fishes and the insects and the life of the rivers and lakes, all as elements of a great complex, and he studied them broadly in their relations to their surroundings. Man himself was his starting ecological factor. In fact, it will be difficult if not impossible to point out a naturalist of his generation who was more original or broader or sounder."

"The Lake as a Microcosm," a lecture delivered by Forbes in 1887 and later printed, is now an acknowledged classic, considered by many to be the first study to recognize animal associations, which are the basis of ecology. Forbes not only considered the environment in his studies of birds, insects, and fishes, but he acknowledged that man and his interests were essential factors in the environments of organisms.

Forbes noted in a paper of 1903 that the interests of plants and animals and those of their enemies—diseases, parasites, and predators—are the same and that natural selection has constantly adjusted this common interest. Whatever injures a plant also injures the insect that feeds on it. Insects, therefore, must not significantly harm the plants on which they depend for food but must take only excess foliage or fruit and prevent the plant species from overcrowding. When an insect becomes too abundant, a reduced food supply reduces the numbers of that insect and the plant species recovers. In Forbes's words, "through an oscillation of indefinite continuance." In short, the concept of the balance of nature.

In developing what he called "economic biology," Forbes believed that the most significant endeavor was the discovery of the laws of oscillation in plants and animals and the deciphering of nature's way of preventing and controlling those oscillations. The first requirement for such discovery, he believed, was "a thorough knowledge of the natural order—an intelligently conducted natural history survey. Without such knowledge, all measures were empirical, temporary, uncertain and often dangerous." What member of the Natural History Survey can disagree today?

Forbes warned that in a comparison of nature's order and the interests of man, there is almost always considerable conflict. The



Stephen A. Forbes
1844–1930

Forbes

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natural order provides for the mere maintenance of the species, whereas man's requirements are much greater. Man urges excessive and superfluous growth and increase of plants and animals, and that all the surplus goes to supply human wants. Numerous disturbances arise from these human interferences with nature's system. Many of the disturbances are dangerous, others Forbes believed were full "of positive evil." The oscillations of species which appear are as injurious to man as they are to the plants and animals more directly involved. For example, most of the serious insect problems result from species whose injurious oscillations come from changes brought about by man. Finally, Forbes concluded, "The main lesson of conduct taught us by these facts and reasonings is that of conservative action and exhaustive inquiry. Reasoning unwarranted by facts, and facts not correctly and sufficiently reasoned out, are equally worthless and dangerous for practical use." What better advice can we receive today?

Radiotracking Relocated Raccoons

Everyone enjoys observing raccoons, with their attractive ringed tails, black banditlike eye masks, and intelligent, sometimes comical, behavior. That is, until one moves into the attic or under the porch or begins tearing into the trash cans at night. Then the handsome raccoon becomes "nuisance wildlife."

Releasing backyard raccoons to rural settings may seem an ideal solution to homeowners, but the problems faced by the relocated racoons are only beginning to be defined.

The Illinois Department of Conservation receives thousands of complaints about nuisance wildlife each year. Often, problems are handled by licensed animal control professionals who respond to complaints by trapping and removing the offending animals. The question then becomes what to do with the removed animals. Many are taken to nature preserves or similar areas and released "into the wild" in the hope that they will find a new home.

Although relocation programs sound simple and are certainly appealing, the solution to the problem of nuisance wildlife may not be quite that easy. Since the 1940s, raccoons have increased to record numbers throughout Illinois, and so have people. There is virtually no place to release a relocated raccoon where there is not already a substantial population of other raccoons or of people. And most nature preserves around urban or suburban areas are relatively small. Certainly no vast wilderness awaits the thousands of animals handled by animal control professionals each year.

The problem is further compounded by the high mortality rate suffered by animals relocated to unfamiliar areas. The best den sites may already be occupied by the resident raccoon population. Displaced animals may wander extensively, have difficulty locating good dens and foraging areas, and ultimately succumb to malnutrition, disease, or traffic. Little is known about the impact of relocated animals on the resident raccoon population or whether relocated animals become problems for people living in rural areas.

In cooperation with the Max McGraw Wildlife Foundation and the Illinois Department of Conservation, the Survey is conducting a two-year study to monitor the movements and survivorship of raccoons relocated from suburban to rural environments in Kane County. Problem raccoons removed from the suburbs are weighed, measured, and fitted with radiocollars before being released into a rural forest preserve. Their daily movements are then followed by radiotelemetry and compared with those of a group of radiocollared raccoons that are original residents of the area.

By monitoring these radiocollared animals, we should be able to address several questions. Do the relocated raccoons find a new home in the preserve, or do they abandon it and move into the surrounding landscape? Do they survive as well as the resident raccoons, or do they quickly become roadkills or succumb to starvation, disease, or other mortality factors? Are the relocated animals more likely to take up residence near human habitations than the rural raccoons?

The answers to these questions will help conservation biologists and managers evaluate the success of current relocation programs and determine the best policies for dealing with the increasing volume of conflicts between people and the wildlife that move into their backyards.

Ed Heske, Center for Wildlife Ecology

Illinois Cropland: Soil Erosion Trends

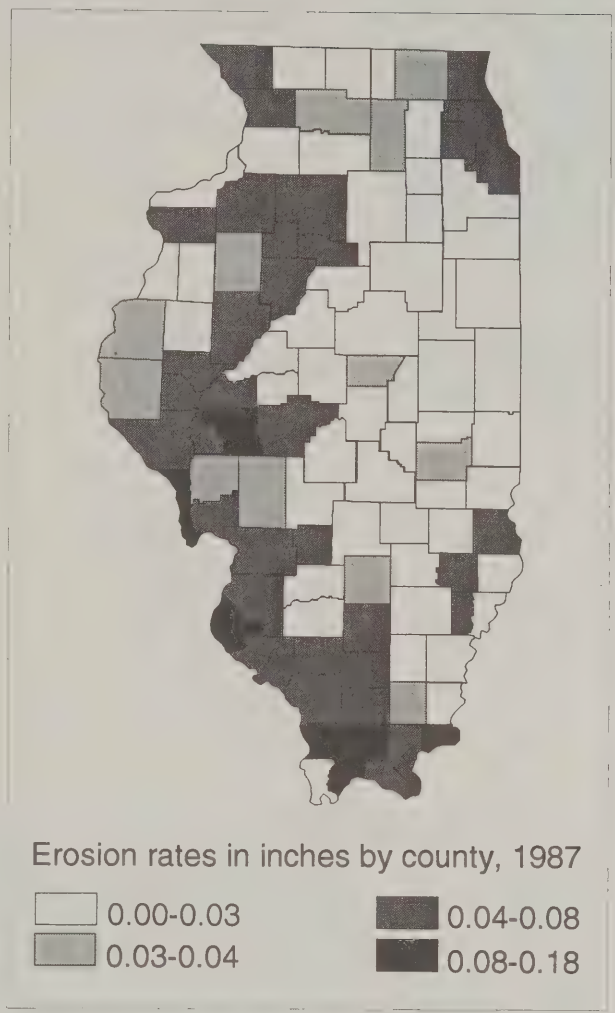
There are three kinds of news about soil erosion on Illinois cropland. The good news: Erosion rates decreased from 1982 to 1987. More modest news: On average, Illinois soil will last several centuries at present rates of loss. The sobering news: In several counties, soil lifetime is only a few decades. Even the average erosion rate represents a loss of about 1.4 pounds of Illinois soil for every pound of corn produced.

About 25 million of the 35 million acres of Illinois are in crops. Erosion rates for all but 6 of the 102 counties in the state (Clinton, Cook, Fayette, Hardin, McHenry, and Pope) show a decrease from 1982 to 1987. The area-weighted mean decreased from 0.044 to 0.034 inches per year in that period. This decrease can probably be attributed to the increasing use since the 1970s of various types of conservation tillage, methods that leave a certain amount of crop residue in the field into which the next year's crops are planted. The soil is less exposed to the elements, and erosion can be reduced up to 95 percent. The acreage fraction under conservation tillage increased from about one-third in 1987 to slightly over half in 1993.

Erosion rates for Illinois counties in 1987 are shown on the map to the right. Much of the Prairie State is indeed relatively flat, but it does have steeper and more dissected areas along rivers and in the driftless area south of the extent of the Wisconsinan glaciation (roughly the southern half of the state). The steeper areas have higher erosion rates, particularly those along the lower Illinois and Mississippi rivers. Of the six counties for which erosion rates increased, four are downstate, but two, McHenry and Cook, are in greater Chicago. The increase in those two may be attributed to rapid land development. As farmland becomes susceptible to development, farmers are less likely to make the investment in new equipment required by conservation tillage.

Static lifetime is a term that refers to soil depth divided by the current erosion rate. Two depths are used in the computation. The first is the depth to bedrock. Sixty inches is the depth given in soil surveys, but in Illinois actual bedrock is usually much deeper. The second is the depth of the A-Horizon and corresponds to what is usually considered topsoil, typically about 8 inches. A-horizon lifetimes in Illinois average about 240 years, but wide variation is found. Several counties, for example, Calhoun, Mercer, and Monroe, have lifetimes of 36, 75, and 82 years, respectively.

An important and as yet unresolved issue about these lifetimes is the role of "T" value, the estimated maximum rate of annual soil erosion that will permit crop productivity to be sustained economically and indefinitely. For Illinois, "T" is considered to be 5 tons per acre per year, the equivalent of 0.033 inches per year. This rate is essentially the same as the average erosion rate in Illinois in 1987. This equivalency would seem to imply that, on average, Illinois soil is being replenished as rapidly as it erodes and that its lifetime is infinite. There is widespread ambiguity, however, in specifying the processes that determine "T," particularly regarding cultivation practices and additions of fertilizer. A number of researchers claim that a "natural" rate of soil formation is considerably less than the "T" value. At present, we do not correct our results for "T," pending further ivestigation.



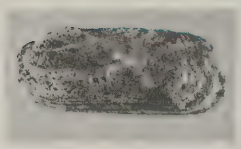
As the map clearly shows, counties with higher erosion rates are located along the lower Illinois and Mississippi rivers and in the southern part of the state beyond the Wisconsinan glaciation.

The relatively low erosion rates found in Illinois (looked at from the standpoint of depletion) nevertheless result in heavy sediment and nutrient loads in rivers, lakes, and streambeds, and those loads have serious impacts on aquatic life and water quality. Even if erosion-prone soils were replenished every year, the downstream effects of erosion are environmentally significant.

Robert Herendeen and Donna Fathke, Center for Aquatic Ecology

Species Spotlight

Rabbitsfoot



Luck seems to be running out for the rabbitsfoot mussel.

A rabbit's foot should bring good luck, but for *Quadrula cylindrica*, an Illinois mussel with the common name of rabbitsfoot, such has not been the case. It is one of 21 mussels that have been placed on the state's endangered species list.

Because the soft body of the rabbitsfoot is enclosed by a two-part shell, it is called a bivalve. Like all fresh water mussels, its shell is made up of three layers—an outer horny covering, a thin calcareous layer, and an inner layer of mother-of-pearl. The outside covering is green to light brown in color with yellow zigzag markings. The surface is rough with knobs and bumps.

The soft body of a rabbitsfoot is attached to the top of the paired shell. The bottom part of the body forms a muscular foot. To move, the mussel extends its foot between the shells. The foot is then wedged into materials on the river bottom and the body is pulled along—much like dragging a ball and chain. Mussels do not move very far or very fast! At the rear are two tubes or siphons. The incurrent siphon brings in water and food and the excurrent siphon expels water and waste.

Rabbitsfoot adults live their entire lives partially embedded in the mixed sand and gravel of medium to large rivers. Historically in Illinois, the species was found in the Wabash, Ohio, Vermilion, and Embarras rivers. At present, it is found only in the North Fork of the Vermilion.

Four stages make up the life cycle of a rabbitsfoot. Males release sperm into the water where they enter the female via her incurrent siphon. The eggs are fertilized internally and develop into small larvae called glochidia. These are stored in the female's gills, which function as a brood pouch. The glochidia are then expelled into the water to begin the parasitic phase of their life. They must attach to the gills of a host fish—whitetail shiners, spotfin shiners, or bigeye chubs—and form cysts. While encysted for 1–6 weeks, the larvae change form and begin to resemble adults. Glochidial infestations are usually light and do not harm the host fish. When the adult structures are formed, including a small shell, the young mussel breaks through the tissue of the fish and falls to the river bottom where it begins an independent life.

Mussels are one of the most endangered groups of animals in North America. Illinois originally had 78 species of mussels; 15 have been extirpated from the state, another 21 are endangered, and 4 are threatened within Illinois. Mussel decline is due to siltation from poor land practices, competition from exotic species, pollution, overharvesting, and stream channelization.

Teacher's Guide to "The Naturalist's Apprentice" (facing page)

OBJECTIVE

to help students understand some of the reasons why some organisms in Illinois are endangered

SKILLS/PROCESSES

map reading and analysis

VOCABULARY

endangered, habitat, range, relict species, endemic

MATERIALS

copies of **Why Endangered?** (facing page)

COMMENTS

A species that is in danger of extinction as a breeding species in our state is listed on the Checklist of Endangered and Threatened Animals and Plants of Illinois. Organisms reach that condition for a number of reasons. Perhaps the most important and widespread threat to the existence of a plant or animal is loss of habitat due to human activity, for example, industrial or agricultural development. Consider that Illinois once had over 21 million acres of tallgrass prairie; today, prairies are reduced to about .01 percent (one hundredths of one percent!) of their original extent. Species disappear for other reasons also. A plant or animal may be at the edge of its range in Illinois. Ranges may expand, but they can also contract and a species at the edge of its range will then be vulnerable. Other species exist in a very narrow range of habitat or even in only a single small area and nowhere else. Such species are called endemic. Any adverse change in habitat could result in a significant decline in an endemic species. Relict species (those that persist in a particular habitat after most of its companion species have disappeared) are also subject to decline when the habitat in which they exist changes, either because of natural processes or human distrbance. Species that persisted in an area even after the glaciers retreated are good examples.

PROCEDURE

1. Distribute copies of **Why Endangered?**.

2. Ask students to read the four reasons for endangerment and match each with the appropriate map. (Answers: 1–A, 2–E, 3–B, 4–C)

3. Discuss with the class why students made their choices. Expand the discussion by asking the following questions and others of your own: What reasons other than the four we have talked about might there be for a species to become endangered in Illinois? *(competition from exotic [nonnative] species, overharvesting by humans).* Why is a state, which is a political unit, concerned about endangered species within its boundaries? (*to preserve its biological resources [a state mandate in Illinois], to maintain genetic variability over the entire range of a species)*

The Naturalist's Apprentice

Why Endangered?

When species of plants and animals in our state become so rare that they are in danger of extinction as a breeding species, they are listed on the Checklist of Endangered and Threatened Animals and Plants of Illinois. The decline of a species occurs for many reasons, four of which are described below. Read each reason and match it with the map that most nearly illustrates the point. *Note: There are more maps than descriptions and each description has only one correct answer. It's a good idea, therefore, to read all of the paragraphs before making your choices.*

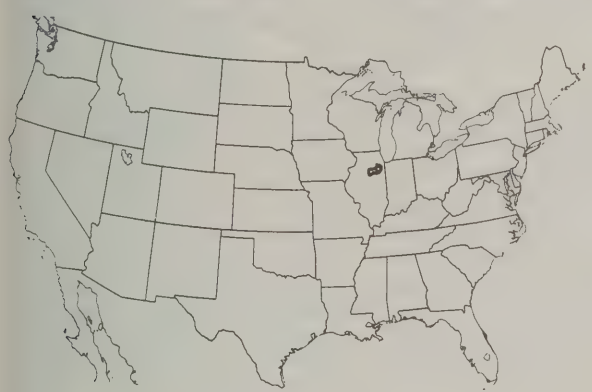
Reason 1: Map _____
The major cause for the decline of most species is habitat loss (they no longer have suitable places to live). Examples of habitat loss include pollution of streams, cutting of forests, plowing of grasslands, and urban development.

Reason 2: Map _____
Plants and animals have what scientists call ranges—regions in which a particular organism occurs naturally. A plant or animal at the edge of its range in Illinois may become endangered when its range shrinks.

Reason 3: Map _____
In some cases, a species of plant or animal may have only a very narrow range and lives there and nowhere else. Such species are called endemic. Illinois has only a few endemic species. Even though these organisms may be as plentiful in our state as they ever were, they are still so rare that they are classified as endangered because any sort of disturbance may cause them to decline or disappear.

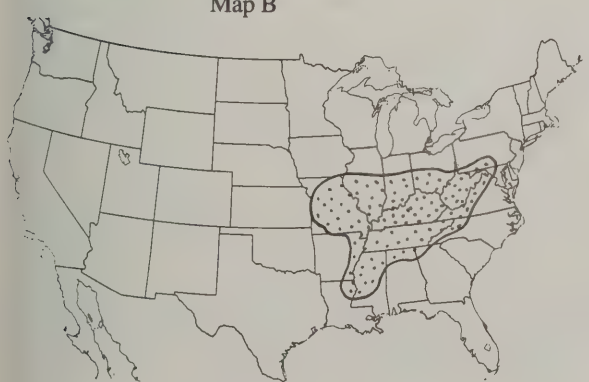
Reason 4: Map _____
Plants or animals that remain behind after the climate or other conditions that originally allowed them to live in an area have drastically changed are called relict species. For example, certain species of plants were found in Illinois when the glaciers were here. As the glaciers melted and the climate warmed, most, but not all, of these organisms died out. A few continue to exist in Illinos.

Forests in 1820 — Map A — Forests Today

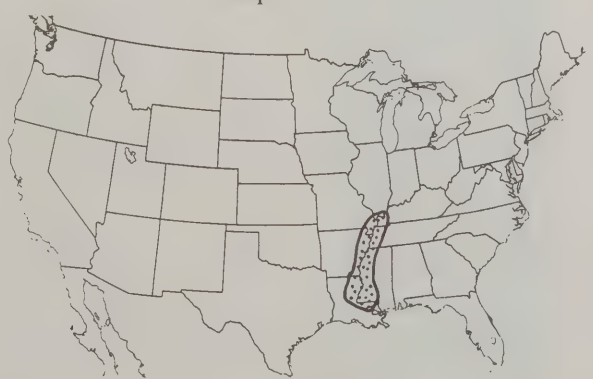


Map B

Map C



Map D



Map E

"The Naturalist's Apprentice" presents educational activities for middle school students. Teachers are invited to photocopy this page for classroom use.

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Update on the Deer Tick

Since the publication of "Deer Tick Watch" in the May/June 1992 issue of *Survey Reports*, the tick, which has become notorious as the vector of the causative agent of Lyme disease, has undergone a change in name. It is now properly referred to as the blacklegged tick. Researchers have demonstrated that the "deer tick," *Ixodes dammini*, actually represents the northern populations of another tick, *Ixodes scapularis*, long known as the blacklegged tick.

Under whatever name, the blacklegged tick is now known from collections in 48 counties of Illinois. Twelve counties were added in the past two years: Champaign, Clark, Cook, Crawford, Franklin, Jackson, Marshall, Randolph, St. Clair, Tazewell, Union, and Williamson. In most of the counties in which the blacklegged tick is known, it is of sporadic and limited occurrence with its known presence based on meager information. In some counties (for example, Carroll, Ogle, Rock Island, and Monroe) and to a lesser extent in a few others (Grundy, Will, and Winnebago), the tick is of predictable occurrence at known sites.

Lyme disease continues to be diagnosed in Illinois but for reasons unknown seems to be declining. According to information recently released by the Illinois Department of Public Health, 51 cases among Illinois residents were reported in 1991, 41 cases in 1992, and 19 in 1993. All cases for the three years were evaluated by the same public health service criteria.

Illinoisans engaged in outdoor work and recreation are again reminded to take precautions against tick bite. Anyone wishing to submit ticks for identification should send them in alcohol to John Bouseman at the Illinois Natural History Survey. The address is given at the top of this page.

John K. Bouseman, Center for Economic Entomology, and Jeffrey A. Nelson, M.D., Rush Presbyterian St. Luke's Medical Center, Chicago, and an affiliate of the Center for Economic Entomology

Shaded areas indicate the known distribution by county of the blacklegged tick, Ixodes scapularis.

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INHS Reports is edited by John Ballenot and printed on recycled paper. Design consulting is provided by Otto-Walker Communications. "The Naturalist's Apprentice" is created by Michael Jeffords, and Susan Post writes "Species Spotlight."

Attention Two-minute Naturalists

Turn to 580 on your AM dial to hear "Illinois Naturalist" brought to you by the Survey through the courtesy of the University of Illinois. This two-minute portion of *Afternoon Magazine* can be heard each Friday at 2:40. The University's FM station was inadvertently listed in the May/June issue of *Survey Reports*.

ILLINOIS NATURAL HISTORY SURVEY

Reports

NATURAL HISTORY SURVEY
AUG 29 1994
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September/
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No. 329

INSIDE

Effects of Edge Types on Indigo Buntings

Indigo Buntings (*Passerina cyanea*) are one of the most abundant and widespread breeding birds in Illinois. Their characteristic song can be heard even in the midday heat in habitats that range from forest interiors to shrubby areas in grassland and on farms. Although the bunting is dependent on edges for nesting, these edges can range from hedgerows and abrupt boundaries between agricultural fields and forests to small natural openings in forests created by treefalls or disturbances associated with streams. We examined the effects of different kinds of edges on nest predation rates and levels of brood parasitism by Brown-headed Cowbirds (*Molothrus ater*) in a variety of sites in extreme southern Illinois. We were particularly interested in determining if nesting success was higher along gradual or "soft" edges along natural openings (for example, treefalls or streamsides) than it was along abrupt, permanent edges created by human activities (for example, forest-farm boundaries or forest openings created by conservation managers). These data might prove useful for managers seeking to increase populations of wildlife that depend on habitat edges rather than forest or grassland interiors.

We conducted this study from 1989–1993 in the western Shawnee National Forest, the Trail of Tears State Forest, and the Cache River Bioreserve. Because we had five years of data from several sites, we were also able to examine effects of annual variation in levels of predation and parasitism.

Based on our review of the literature, we predicted that nest predation rates and cowbird parasitism levels would be higher along abrupt, permanent edges. Populations of many nest predators are widely believed to be enhanced in habitats with permanent edges, and it has been hypothesized that abrupt edges increase the searching efficiency of predators and cowbirds.

Results strongly supported our prediction for predation rates but not for cowbird parasitism levels. Cowbird parasitism showed strong annual and site-to-site variation but no differences related to edge type. Nest predation rates showed the opposite pattern, with strong differences among edge types but no significant differences among years and study sites. Daily nest predation rates were nearly twice as high on abrupt, permanent edges along agricultural land, old fields, and openings created by conservation managers than they were on more gradual, natural edges along treefalls and streams. Nest predation rates were also comparatively low along regenerating openings created by selective logging. Predation levels were so high along abrupt edges (75–90%) that these habitats might be considered "ecological traps" that attract edge-nesting birds but fail to provide safe nest sites.

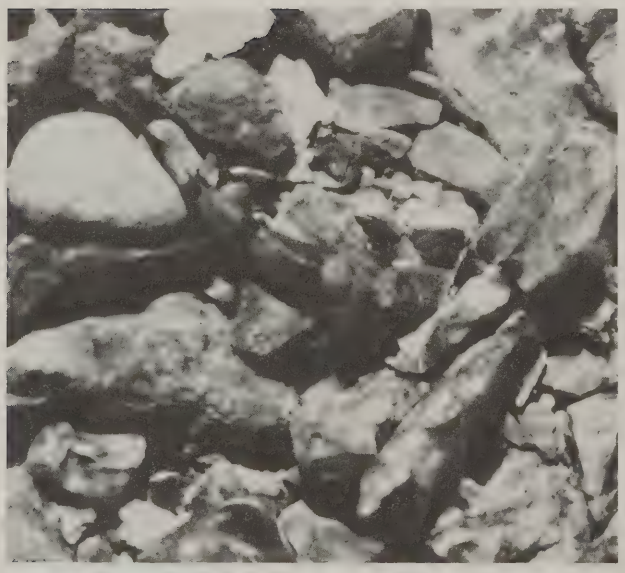
Our results suggest that managers developing strategies to promote edge-breeding wildlife should consider the kinds of edges being created. Permanent edges such as those that have been made around small (<3 acre) wildlife openings may pose problems for some wildlife populations by increasing the number of nest predators. More gradual, "feathered" edges may be preferable to abrupt edges. Selective logging might mimic natural disturbances effectively, at least for some species.

An Indigo Bunting nest that escaped predation. Nest predation rates reached 90 percent along some abrupt edges, and such a habitat might attract buntings but fail to provide a safe nest site.

Scott K. Robinson, Andy Suarez, and Karin Congdon, Center for Wildlife Ecology

Color Patterns as Camouflage in Fishes

Unrelated animal species commonly share similar color patterns. One pattern that is particularly common in bottom-dwelling fishes has four saddles (dark, rectangular blotches on the back) with three lighter intervening spaces, the largest of which is closest to the head. Examples of the four-saddle pattern are found in both freshwater and marine fishes throughout the world. Examples in Illinois include the rainbow darter, hogsucker, banded sculpin, walleye, and the extirpated crystal and stargazing darters. No explanation of why this pattern is so common or why it almost always consists of four saddles has been suggested. Because the pattern is found in several fishes that have declined in abundance in Illinois, Survey scientists investigated the function of the pattern by examining the ecology of fishes exhibiting it and by comparing the spacing of the saddles on several species.



Find the fish. This banded sculpin from southern Illinois uses disruptive coloration to break its body outline into a series of "rocks."

Saddles or other dark bars can serve to camouflage animals in two ways: obliterative countershading and disruptive coloration. Obliterative countershading works as a camouflage because of the way the eye perceives the pattern and not the background against which the animal is viewed. A zebra seen in broad daylight, for example, is conspicuous; however, predators of zebras are most active at dawn and dusk in lower light levels. In low light, the zebra's stripes are too close together for the eye of a predator to resolve the pattern, and the zebra disappears into the background. Disruptive coloration, on the other hand, depends entirely on the background against which the animal is viewed because the color pattern breaks the configuration of the animal into elements similar to those of the background.

We examined the substrate (and, thus, the background) preferences of North American freshwater fishes to determine which camouflage method four-saddled fishes employ. We hypothesized that if four-saddled species relied on obliterative countershading, they would live as commonly on homogeneously colored substrates (sand or mud) as on more complex substrates (gravel). If the fishes were using disruptive coloration, they would be found only on gravel, with the lighter spaces mimicking rocks and the darker saddles blending with shadows or gaps between rocks.

We determined substrate preferences for 269 species in four large groups of North American fishes: suckers, catfishes, darters and sculpins. Of these, 49 species have the four-saddle pattern, and all 49 prefer gravel substrates as predicted by our disruptive coloration hypothesis. In further support of disruptive coloration, whenever we captured banded sculpins over sand, they did not have saddles but were uniformly colored instead.

The exact placement of the four saddles on the bodies of five species of fishes were compared to determine whether spacing was important. The exact placement of the saddles differed statistically among the species, but the saddles were always unevenly spaced. In four of the five species, spaces between saddles increased in size toward the head. Because rocks come in various sizes and are randomly scattered, a fish is more cryptic (likely to be concealed) with an uneven pattern than with an even one. Because a fish's body tapers from head to tail, the longest spaces on the widest part of the body tend to produce round or square spaces that blend effectively with a gravel substrate (most rocks are round rather than oblong).

The fifth species, the checkered madtom (a catfish), had a more evenly spaced pattern of saddles. Apparently, checkered madtoms can sacrifice the increased crypsis provided by an uneven pattern because they are active only at night and have poison glands at the bases of their fin spines to discourage predators.

Because the four-saddle pattern has evolved in fishes that live on gravel substrates, their survival may be negatively affected by increased siltation in streams. As silt covers the gravel, the substrate becomes a uniform color and saddled fishes become increasingly visible. Interestingly, two of the most endangered fish species in the United States, the snail darter and the Maryland darter, exhibit the four-saddle pattern. In Illinois, the crystal darter and the stargazing darter are extirpated, and the range of the rainbow darter has decreased. Siltation is a factor in the decline of these fishes for many reasons, possibly including a decrease in their ability to hide from predators.

Jonathan W. Armbruster and Lawrence M. Page, Center for Biodiversity

Potato Leafhopper: A Serious Migratory Pest in Illinois

The potato leafhopper (*Empoasca fabae*), a serious pest of alfalfa as well as other legume crops in Illinois, is a small wedge-shaped pale green insect about a quarter inch long. During the summer, it can often be seen on windows at night or around porch lights. Gardeners occasionally find these insects damaging their snap beans.

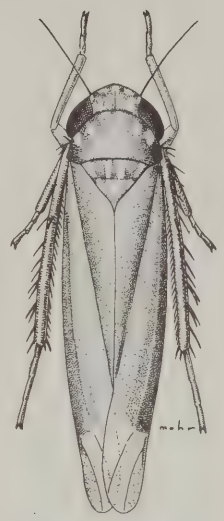
Each year potato leafhoppers migrate into central Illinois in late April or May. Their source has been traced to the southern states, primarily Louisiana. Because these insects do not overwinter in northern states, initial populations must develop each year from a spring migration. Survey researchers, in cooperation with entomologists in other states, are studying spring migration as well as interhabitat migration between various crops and woodlands. Large numbers of leafhoppers move from the South with weather fronts, and when conditions are favorable, they fall to earth. Management of agricultural crops influences movements within and between fields. To study this movement, sticky yellow traps are placed in and around various habitats to collect migrating adults.

Growers of alfalfa need to be aware of the potential for damage by this insect on the second and subsequent hay crops. The adults cause v-shaped yellowing of alfalfa leaves, but by the time yellowing is evident, the plant has already been damaged. The damage is characterized by a loss of protein content and a stunting that reduces hay yield.

Populations of potato leafhopper usually decline in late August, but reductions may occur earlier as a result of a naturally occurring fungal pathogen. This pathogen produces infective spores which when they come into contact with a leafhopper, usually in its immature stages, germinate and grow through the skin of the insect. The fungus continues to grow and spread throughout the body cavity of the infected host until it kills the insect, in about three days. By the time the insect dies, it has been attached to the surface of the plant by small strands of the fungus which have grown out of the insect's body. These strands continue to grow until they have covered the insect with a cottony mass. During periods of high humidity, this mass produces more spores that infect other leafhoppers. Some infected insects produce overwintering resting spores within their body cavities, and these ultimately end up on the surface of the soil where they will germinate the following season to repeat the cycle.

When potato leafhopper nymphs are infected on a current hay crop, future adult populations will be reduced and will often remain below the economic threshold for the remainder of the season. The potato leafhopper fungus occurs only in northern latitudes and appears to be limited by higher temperatures in the South. Researchers hope to discover a strain of the fungus that is more heat tolerant. If they succeed, this natural control of the potato leafhopper can begin its work in the southern states, the source of Illinois leafhoppers.

Stephen. J. Roberts, Center for Economic Entomology



The potato leafhopper, a serious pest of legume crops in Illiniois, is a wedge-shaped pale green insect about a quarter inch long.

New Publications from the Survey

The Survey is pleased to announce four new publications. Each can be ordered from the Distribution Center, Illinois Natural History Survey, Natural Resources Building, 607 East Peabody Drive, Champaign, Illinois 61820. Descriptions and prices are given below.

The Wetland Resources of Illinois: An Analysis and Atlas was released as Special Publication 15 and sells for $4.00. Coauthored by Liane Suloway and Marvin Hubbell, the 88-page book is a valuable reference for resource planners and managers, environmental scientists, policy makers, and others interested in wetland resources. Its 23 maps provide detailed information on the character, extent, and distribution of wetlands and deepwater habitats in Illinois. The publication relies on geographic information system technology and provides much needed base-line data for future wetland research as well as for the restoration and creation of wetlands.

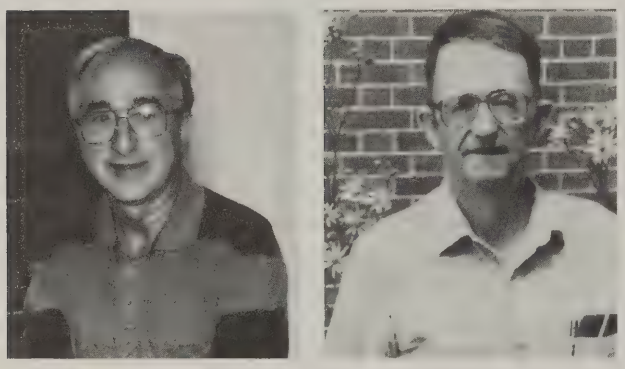
Biological Notes 139, *Behavior, Dispersal, and Survival of Male White-tailed Deer in Illinois*, was written by Charles M. Nixon and colleagues from the Survey, the Missouri and Illinois departments of conservation, and Western Illinois University. It reports on ten years of research at three widely separated sites in Illinois. The publication is priced at $3.00.

Mighty Miniatures, an educational package for teachers, youth leaders, and parents, introduces elementary and middle school students to the world of insects. The package includes a poster large enough for coloring and a 20-page activity guide. The poster is printed on both sides. One side describes

(Continued on back page)

Survey Retirees: A Double Adieu

This past summer brought the retirement of two of the Survey's scientists of long standing, Dr. Wallace E. LaBerge and Charles M. Nixon. Both men have achieved national prominence in their fields, and both are respected by their colleagues within the state and throughout the country. They will be missed at the Survey, but their contributions will stand as a record of their achievements.



Wallace E. LaBerge (left) and Charles M. Nixon (right) retired from the Survey this past summer. Each served the Survey and the state for more than a quarter of a century, and they will be missed both professionally and personally by their colleagues.

After twenty-nine highly productive years at the Natural History Survey, Dr. Wallace E. LaBerge retired on 30 June 1994. He has been granted an emeritus appointment by the Board of Natural Resources and Conservation and will continue with his systematics research on the family Andrenidae (solitary bees) for which he is world renowned.

Dr. LaBerge received a doctorate in entomology from the University of Kansas in 1955 and accepted an appointment to the Survey in 1965 following teaching positions at the University of Kansas, Iowa State, and the University of Nebraska. During his distinguished career, he has published 69 papers (more than 3,000 pages) pertaining to the systematics, ecology, evolution, and zoogeography of native bees and ants. His 70th paper is soon to be published. Dr. LaBerge has maintained an outstanding record for obtaining funds to support his research and has consistently obtained grants from the National Science Foundation.

In 1969, Dr. LaBerge achieved the rank of Professional Scientist at the Survey and was named Adjunct Professor at the Urbana-Champaign campus of the University of Illinois. In addition to his remarkable research career, he has served in several administrative capacities—as Head of the Section of Faunistic Surveys and Insect Identification from 1979 through 1989, as Acting Chief of the Survey in 1980, and as Director of the Systematics Program at the National Science Foundation during 1982.

When the insect collection at the Natural History Survey exceeded the capacity of its storage facilities, Wally was chiefly responsible for obtaining funds to purchase the compactors that would accommodate the accelerated growth of this important collection of 6,000,000 specimens.

Wally's dedication to the Survey and his many contributions to the field of entomology have been exemplary. He has served his fellow scientists well and has provided an outstanding role model for younger members of the staff. The Survey has indeed been fortunate in his long tenure, and his colleagues are pleased that he will continue his research during his retirement.

Charles M. ("Chuck") Nixon, Professional Scientist with the Natural History Survey, retired 15 July 1994, after nearly 25 years with the Center for Wildlife Ecology. Born in Massachusetts, Chuck received degrees in biology and wildlife management from Northeastern University and Penn State University, respectively. Before coming to the Survey, he was employed as a research biologist for the Ohio Department of Natural Resources from 1959 to 1970.

Chuck's primary research interests are in forest wildlife ecology, a field in which he has become a national leader. During his Ohio tenure, he conducted research on wild turkeys, squirrels, deer, and beaver but was also involved in studies on small mammals, the ring-necked pheasant and ruffed grouse, and amphibians and reptiles. At the Survey, Chuck led the research on gray and fox squirrels and white-tailed deer and, since 1989, headed cooperative research on the racoon with fellow scientists from Western Illinois University and the College of Veterinary Medicine at the University of Illinois.

While at the Survey, Chuck has authored or coauthored some 37 refereed publications. Major contributions have been studies on the distribution and abundance of the gray squirrel in Illinois, squirrel hunting in Illinois, managing forests to maintain populations of gray and fox squirrels, and ecology of white-tailed deer in an intensively farmed region of the state. He has also contributed five chapters to books.

Chuck and his wife Eileen plan to continue to live in Monticello. The word is out that fish in east-central Illinois are advised to keep their mouths shut now that Chuck has retired.

Kathleen R. Methven, Center for Biodiversity, and Glen C. Sanderson, Center for Wildlife Ecology

Goose Lake Prairie: A Visit to the Past

Vast expanses of tallgrass prairie once covered central and northern Illinois. Unfortunately, more than 99 percent of that prairie is now gone and the little that remains is found only in small patches, typically less than five acres. A notable exception is Goose Lake Prairie State Park in Grundy County. Over 1,600 acres of prairie make this area unique in Illinois. Here we can view a virtually uninterrupted expanse of tallgrass prairie and verify the observations of early settlers who equated the prairie with "a sea of grass." The grassland undulates in the breeze, punctuated by small dips and hollows occupied by marshes and ponds.

The park was established in 1969 and originally contained more than 600 acres of farmland that has been maintained to produce forage for waterfowl and other wildlife. The Illinois Department of Conservation, however, soon began converting small parcels of farmland to prairie. In recent years, perhaps a reflection of our changing conservation values, these restorations have accelerated and now include the entire 600 acres.

Goose Lake is also used for research, including the effects of browsing deer on prairie flora and the effects of fire on prairie insect populations. On-going programs track some of the largest populations of prairie birds in Illinois, a group that has been declining precipitously since the 1950s.

From midsummer through first frost, many of the more spectacular prairie wildflowers are in bloom. Lead plant, blazing star, and rattlesnake master are followed by late-season coreopsis, prairie dock, and a host of others. Five miles of interpretive trails offer visitors an excellent view of the prairie pothole marshes that once dotted the Illinois landscape. Rare Henslow's sparrows hiccup atop the flower stalks of prairie dock. Summer hikers will also see white-tailed deer and an array of prairie butterflies, including the great spangled fritillary.

A visitors center provides interpretive exhibits and is open from 10 A.M. until 4 P.M., seven days a week. To reach Goose Lake Prairie State Park, take Route 47 south from Morris to Pine Bluff Road. Head east for about seven miles to the park and enter a landscape that time has forgotten—the tallgrass prairie of Illinois.

Mark Schwartz, Center for Biodiversity, and Michael Jeffords, Center for Economic Entomology

A monarch butterfly on its way south stops to visit a blazing star in late summer.

Soy Beans: Key to a New Mosquito Larvicide?

Some of the most dreaded diseases are carried by blood-sucking mosquitoes. In Illinois, 62 species are either nuisances or, much more seriously, transmit pathogens that cause disease in man and animals. Options for control, however, are decreasing at an alarming rate because mosquitoes have developed resistance to chemical formulations, because of growing environmental concerns related to the use of insecticides, and because of the cost associated with the federal registration of new products.

Petroleum distillates have been used for nearly a century to control insect pests that endanger public health as well as those that damage greenhouse plants, fruit trees, and vegetable crops. Fuel oils (kerosene or diesel fuel) mixed with crankcase oils, mineral oils, and surfactants (surface-active agents) were once a common means of controlling mosquitoes in aquatic habitats—swamps, marshes, sewage lagoons, rain barrels. Most of these highly refined mixtures of petroleum distillates are able to mix with water after the addition of emulsifiers. The oil kills the insect by interfering with its respiration, eventually causing it to suffocate. Petroleum-based oils, however, are not readily biodegradable and can harm nontarget insects and other animals and plants. Petroleum-based oils were once a mainstay for mosquito control, but now all but one of these products is off the market.

We hope to demonstrate that soy oils can replace petroleum-based formulations for the control of mosquitoes. Our initial investigations will screen soy oil formulations along with a variety of additives meant to enhance the physical, chemical, and insecticidal properties of the basic soy oils. Tests will also tell us how well various formulations spread and mix with water and how long their effectiveness persists. After products have proved successful in the laboratory, we will evaluate their performance under field conditions, including the metabolism and breakdown of the oils and additives, the impact on nontarget organisms, and toxicity to pest insects other than mosquitoes.

A multidisciplinary approach is essential if this project is to be successful. The research team consists of Dr. Robert Novak, a specialist in mosquito ecology, surveillance, and control; Dr. David

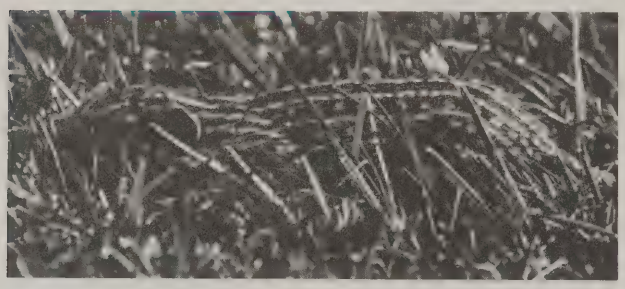
(Continued on back page)

Species Spotlight

Thirteen-lined Ground Squirrel

Mention the thirteen-lined ground squirrel to researchers on the South Farms at the University of Illinois and they quickly shout, "You have to have border rows and try a plastic snake or owl!" I speak from experience—last season ground squirrels ate 1,640 of 1,900 hills of oats from my research plots.

The thirteen-lined ground squirrel, *Spermophilus tridecemlineatus*, is a tan or buffy color with thirteen whitish stripes, some continuous and others interrupted to form rows of spots. The alternating pale and dark stripes break up the body outline, offering camouflage amidst the grass stems, patches of bare soil, and shadows of its grassy habitat. These squirrels range in size from 7 inches to a foot and have a tail half the length of head and body. In Illinois, they occur north of a line between Madison and Clark counties, an area that corresponds to the Shelbyville glacial moraine. South of there, the soil is shallow with an underlying hardpan that may prevent these squirrels from digging burrows that are deep enough.



As this photograph clearly shows, the thirteen-lined ground squirrel has an effective camouflage. Its body outline almost disappears in its grassy habit.

These squirrels live underground, but their burrows, unlike those of their ground-dwelling relatives, are not marked by a soil mound. When they excavate, they fill their cheek pouches with earth and carry it some distance before scattering it. Soil around the burrow entrance is packed down, often with the top of the squirrel's head. Burrows are 1 to 1.5 feet underground. Hibernation burrows are deeper, several inches below the frost line, and are used from mid-November to March.

Ground squirrels mate in mid-April, and young are born mid- to late May. Young in litters of five to eight are born hairless with poorly developed limbs. By three weeks their eyes are open, and after a month they emerge above ground to tumble and play with their siblings. They soon establish burrows of their own and put on fat for the coming hibernation.

Thirteen-lined ground squirrels are diurnal and spend most of their time foraging and carrying food to underground storehouses. Their diet consists not only of my oats but includes grasses, seeds, weeds, and insects. They live in grasslands where vegetation is low; when they sit up on their hind legs, they can see over the top of the vegetation. Thus grassy areas that are cut, such as cemeteries, large lawns, and closely cropped pastures, make ideal habitats. Unlike many animals that have declined with human development, this squirrel has found the managed landscape we humans are so fond of equally to its liking.

Teacher's Guide to "The Naturalist's Apprentice" (facing page)

OBJECTIVE

to understand what constitutes a habitat and to find homes for plants and animals that live in three broad habitats (prairies, forests, and wetlands).

SKILLS AND PROCESSES

deduction, seeing relationships

VOCABULARY

habitat, adaptation, canopy

MATERIALS

multiple copies of **Match That Habitat** (facing page), colored pencils or crayons

COMMENTS

Begin by discussing what makes a habitat. In its simplest terms, a habitat is the place where an organism lives. Habitats may be as relatively uncomplicated as your front lawn or as complex and diverse as a local woodland. A more complete definition would be that a habitat contains everything an organism needs to survive—food, water, shelter, and space. Illinois has more than 90 different types of habitats, including seeps and bogs, hill prairies and flatwoods. For *The Naturalist's Apprentice*, however, we will clump all Illinois habitats into three groups: forests, prairies, and wetlands. A forest is an area dominated by trees, usually with a closed canopy. A prairie is generally treeless and dominated by grasses. Wetlands have standing water for part of the year and may be grassy, shrubby, or forested.

PROCEDURE

1. Through discussion, help students to arrive at a working definition of habitat. Reinforce the concept by asking them to describe the habitat in which they live. What kinds of habitats do their pets (birds, fish, guinea pigs) occupy? Can they think of ways in which animals are restricted to particular habitats or denied others?

2. Distribute copies of **Match That Habitat** and ask students to draw a line from each plant or animal shown there to the picture of an appropriate habitat—the best place for that organism to live. Students will need to use a pencil or crayon of a different color to designate each habitat.

3. Discuss the choices made by the class. Is more than one habitat suitable for a given organism? List on the chalkboard ways in which the three habitats differ from one another. Do any of the organisms have special adaptations for living in a particular habitat? Briefly, adaptations are characteristics that make living in a particular place easier or even essential.

The Naturalist's Apprentice

Match That Habitat

Study the three habitats and the plants and animals shown below and give each a name. Write the names of the habitats in the spaces provided. Draw lines from each plant or animal to the habitat where it is most likely to live. Use a pencil or a crayon of a different color for each habitat.

1. _____

2. _____

3. _____

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insects by nine characteristics: aquatic, beneficial, carnivorous, cryptic, herbivorous, mimics, pests, recyclers, and territorial. The other side pictures plants and the butterflies that are attracted to them. Both plants and butterflies are native to Illinois. The activity guide includes a general introduction to insects and five activities that can be adapted for young entomologists in grades three through eight. Youngsters learn the major parts of an insect and interesting adaptations found in the insect world. Matching activities, outdoor fun, and opportunities for writing are included. A copy of the booklet and a set of 30 posters is available for $7.00. For information about other educational materials, request a copy of the Survey's publication catalog. To arrange workshops for teachers or classroom presentations for students, contact Michael Jeffords, Education Liaison, at the Survey.

The Survey's annual report for 1993–1994 is now available at no charge. It features one-paragraph summaries of the more than 200 research projects currently under way at the Survey and its field stations throughout the state. It also includes a bibliography of staff publications.

Larvicides

continued from page 5

Seigler, an expert in the chemistry of biologically active plant compounds; and Dr. Robert Metcalf, a specialist in insecticide chemistry, pest management, and the chemical ecology of insects.

Because the larval control of mosquitoes requires a high level of surveillance and is labor intensive, we chose mosquitoes as the initial target insect. In addition, mosquitoes are restricted to well-defined areas for at least part of their life cycle. Insecticidal oils (primarily petroleum distillates) are effective controls, but environmental concerns and phytotoxicity has limited their use and few alternative chemical and nonchemical controls are available. Modern transportation also allows disease-carrying species like *Aedes albopictus*, the Asian tiger mosquito, to invade new areas and establish themselves rapidly. Finally, recent legislation to protect and promote wetlands virtually guarantees future problems with mosquitoes.

Through secondary investigations we hope to establish the feasibility of soy oils in the management of such greenhouse pests as whiteflies, mealybugs, and aphids. Among our objectives will be to determine the toxicity of soy oils to greenhouse pests, their spreading and adhering properties on plants, and their toxicity to an array of grasses and greenhouse plants. Whiteflies are a feasible target species because they share characteristics with mosquitoes. They are, for example, relatively localized on plants and control alternatives are limited. As with mosquitoes, insecticidal oils are an important component of horticultural pest management. Treatments in some instances rely in part on the use of other insects to keep pest populations under control. When one insect is used as a biological control for another, the toxicity of chemical formulations is a crucial factor.

The use of insecticidal additives with oils combines the action of the oil with the slow release of insect toxicants. One group of additives that we will study includes such insecticidally active botanical derivatives as limonene, terpeneol, piperitone, and azadirachtin and biologically safe agents like *Bacillus thuringiensis israelensis* (Bti). These compounds and the oils of many plants also offer new sources of natural insecticides and repellents for mosquitoes and other insects. Because these chemicals come from natural sources and are biodegradable, they are likely to prove environmentally sound. Water and mosquitoes go hand in hand, and soy beans could play a major role in the control of this disease-carrying pest.

Richard Lampman and Robert Novak, Center for Economic Entomology

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ILLINOIS NATURAL HISTORY SURVEY

Reports

NATURAL HISTORY SURVEY

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November/ December 1994 No. 330

INSIDE

Gateway to Invasion

The zebra mussel (*Dreissena polymorpha*) may be the first foreign aquatic pest to invade the Mississippi drainage through the Great Lakes at Chicago, but it will not be the last. At least five other potential pest species are known to occur near this Chicago gateway. The northern Mississippi Basin and the rivers of Europe were once separated by a wide expanse of sea water, freshwater barriers such as Niagara Falls, and the drainage divide at Chicago. One by one, these barriers have fallen.

In 1900, the flow of the Chicago River was reversed, so water could flow by gravity from Lake Michigan, "up" the south branch of the Chicago River, then down the newly-completed Chicago Sanitary and Ship Canal and eventually into the Illinois. As its name indicates, one purpose of the canal was to carry waste away from Chicago, and thus maintain a clean drinking water supply in Lake Michigan. For a time, this waste created a pollution barrier isolating the Mississippi Basin from Great Lakes invaders. It is ironic that improved control of industrial and urban pollution over the last two decades has lowered this final barrier. The increase in commercial and recreational boat traffic over this same period in the inland waterways created a particularly ripe opportunity for an organism like the European zebra mussel which can attach to boats and hitchhike throughout the waterway system.

The zebra mussel (*Dreissena polymorpha*) may be the first foreign aquatic pest to invade the Mississippi drainage through the Great Lakes at Chicago, but it will not be the last.

The zebra mussel was probably introduced to the Great Lakes in 1985 or 1986. By 1991, huge colonies were blocking water intake pipes in portions of the lakes, and the first individuals were showing up in the Illinois River and upper Mississippi River.

The population exploded in the lower Illinois River in 1993, where small (5/16 inch) mussels carpeted the bottom at average densities of 61,000 animals per square meter (m^2 = about 1 square yard). Oxygen levels in this portion of the river fell to 3.0 parts per million (ppm) on 31 August 1993 and to 1.5 ppm on 29 June 1994, well below the state water quality standard of 5 ppm. Although substandard oxygen levels of 3.6–4.9 ppm had been a problem in this part of the river for at least nine years prior to 1993, the extremely low 1993-94 levels may be attributable to additional oxygen demand exerted by the zebra mussels. The low oxygen levels in combination with warm summer temperatures of 31°C (88°F) apparently stressed the mussels because populations in the lower river declined to only 4,000/m^2 by August 1994, and divers found up to 3,000 empty zebra mussel shells/m^2. Unfortunately, the low oxygen levels probably stressed native aquatic animals as well. As zebra mussels and other aquatic organisms die, the decomposition of their remains uses up additional oxygen, making a bad situation worse.

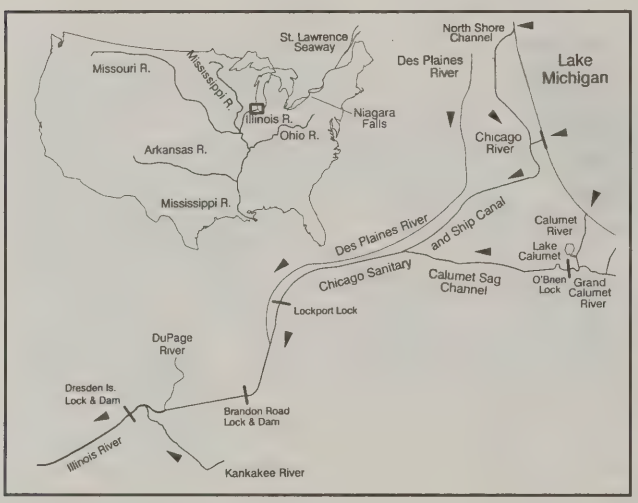
Photo by Richard Sparks, INHS Center for Aquatic Ecology

INHS divers sampling mussel populations in the Illinois river

Zebra Mussels

continued from page 1

Zebra mussel populations elsewhere in the Illinois River and upper Mississippi River are building up gradually, rather than explosively, and oxygen levels are not yet low. In the Illinois River at Peoria, the populations increased from about 2,000/m^2 in 1993 to about 6,000/m^2 in July 1994. At Rock Island on the Mississippi, divers found only 1-2 zebra mussels/m^2 in July, 1994, but the numbers averaged 48/m^2 in August. At another site 240 miles downstream, divers found no zebra mussels. These gradual, patchy increases are probably attributable to sporadic low density settlement of larvae drifting downstream from relatively small populations of adults that were carried into upstream areas by boats.



Map of the Chicago area waterways connecting Lake Michigan to the Illinois River. Inset: map of North America, with the Mississippi and Great Lakes/St. Lawrence drainages. (Map, courtesy of Douglas Blodgett, INHS Center for Aquatic Ecology.)

The massive settlement in the lower Illinois River must have originated from much denser populations of adults somewhere in the upper Illinois River or perhaps southern Lake Michigan. If events elsewhere follow the pattern in the lower Illinois River, these explosions will be followed by crashes attributable to competition and deteriorating environmental conditions.

Wild swings in zebra mussel populations and environmental conditions will be very hard on native aquatic life. These swings could threaten sanctuaries and set back years of recovery attributable to improvements in water quality. In the upper Illinois River zebra mussels could threaten five native mussel species that recently recolonized an area where no mussels could exist in 1969. Over thirty native species, including the federally endangered Higgin's-eye (*Lampsilis higginsii*) and federally threatened spectacle case (*Cumberlandia monodonta*) occur in mussel sanctuaries the Illinois Department of Conservation established on the upper Mississippi River, where zebra mussels are gradually increasing.

The experience with introduced aquatic pests such as the common carp, the sea lamprey, and now the zebra mussel should convince anyone that it is far more effective to close the barn door before all the horses get out. Legislation now requires ocean-going ships to discharge freshwater ballast while they are still in salt water, before they reach the Great Lakes. It remains to be seen how effective this legislation will be; it certainly depends on strict compliance, monitoring, and enforcement.

Introducing nonnative mussel-eating fish to consume zebra mussels is highly questionable because these fish may prey on native snails, clams, and juvenile mussels before they get to the zebra mussels. This is unnecessary because there are several species of native fish and ducks that consume zebra mussels. Whether introduced or native, mollusk-eaters are unlikely to eliminate zebra mussels because predator populations are limited by more than just the food supply; spawning or wintering habitat may be more critical, for example.

We also do not know whether introduced species carry pests and diseases of their own, or serve as supplemental hosts for native parasites. In either case, the incidence of parasitism and disease in native fish and mollusks could increase. When the Asian grass carp (*Ctenopharyngodon idella*) was intentionally introduced by the Arkansas Game and Fish Commission to control aquatic plants, it carried a parasitic Asian tapeworm that infected the native red shiner (*Notropis lutrensis*).

Although no one wants to block pest invasions by restoring the pollution barrier at the Chicago gateway, serious attention should be given to reducing their access to the Mississippi system. Other options include ultrasound, thermal, or chemical barriers in the lock chambers between Lake Michigan and the Chicago waterways, or in locks and constricted points further downstream. A side benefit of the dispersal barrier might be to reduce the number of zebra mussel larvae that are now seeding the lower Illinois River, if in fact the larvae are coming from the canal system or Lake Michigan.

Richard Sparks, with Scott Whitney, James Stoeckel, Eric Ratcliff, Steven Stenzel, Ruth Sparks, Douglas Blodgett, Ellen Marsden, and Daniel Schneider, Center for Aquatic Ecology, and with information from M.S. Millar and Randy L. Eshenroder, Great Lakes Fishery Commission.

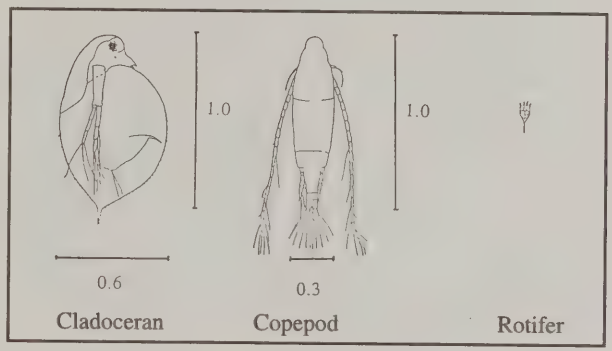
Larval Fish Feeding and Growth

Virtually all species of fish consume zooplankton during part or all of their early development. Their chances of survival may in part be determined by the availability of suitable zooplankton prey during the first few weeks of life. This may be the case for the walleye (*Stizostedion vitreum*) which grows to be a large fish-eating predator, but when young relies on several taxa of zooplankton prey items. Most of the common species of freshwater zooplankton in North America fall into three taxonomic groups; cladocerans, copepods, and rotifers. Cladocerans are round-bodied and relatively slow moving, frequently with spines, while copepods are more slender and move with a quick darting motion. Rotifer shapes vary greatly, but they are always small in relation to the other two taxa (see drawing). The differences in shape, size, and overall abundance of prey may interact with the size of fish to determine which sorts of prey the walleye choose to eat. The prey which young walleye consume may in turn affect the fish's ability to grow and survive.

We conducted experiments in the laboratory and in field enclosures to examine the effects of prey taxa, size, and abundance on the foraging and success of young walleye. We divided the fish into three size groups representing large changes in morphology and behavior: small larvae (8–10 mm); large larvae (11–18 mm); and early juveniles (> 19 mm). In order to determine whether young walleye selectively consume certain types of prey, we let them feed on mixed assemblages of zooplankton which included a variety of taxa and sizes across a range of densities. All sizes of fish avoided eating rotifers, even when they were abundant. Both taxa and size of prey appear to be important in determining prey selection, though their effect differs with size of the fish. In both laboratory and field enclosure experiments, small larvae selectively consumed medium sized (0.4–0.9 mm) cladocerans and avoided large (> 0.9 mm) prey of both cladocerans and copepods. Large larvae also preferred medium sized cladocerans, but selected against small (< 0.4 mm) prey of both taxa. Early juvenile fish selected prey based primarily on size, selecting against all small prey. We found that prey taxa and size, but not density, interact with the size of the fish to influence selection of prey.

In order to test the advantages of different prey taxa for different sizes of walleye, we reared fish in the lab with either cladoceran, copepod, or rotifer prey. Though we did not detect differences in growth rates when fish were raised with different taxa of prey, we did see differences in survival rates. Both small larvae and large larvae survived better when they consumed cladoceran rather than copepod prey. Early juvenile fish fared equally well with all prey taxa. However, both size classes of smaller fish selected for medium cladocerans and had increased survival with cladoceran prey, indicating that prey selection may lead to better success.

The differences in body shape of cladocerans and copepods may help explain patterns of selectivity and, hence, the advantage conferred by cladoceran prey on smaller fish. The round shape of cladocerans may be easier for smaller fish to detect. However, the greater width of cladocerans, especially large individuals, may impede consumption by smaller fish. Laboratory experiments in which we recorded walleyes attempting to feed on two sizes of copepod or cladoceran prey supported this idea. When large larvae fed on large cladoceran prey, they frequently and repeatedly turned towards prey though they were very inefficient at capturing these prey items. Apparently, the large cladocerans provide a strong visual stimuli to small fish, inducing them to attack more frequently.



Shapes and relative sizes of three taxa of zooplankton used in the walleye feeding studies. (Drawing, courtesy of Christine M. Mayer, INHS Center for Aquatic Ecology.)

We found that taxa and size of prey interact with the size of the fish to influence prey selection. Also, we saw that prey type may affect survival in young fish, and may therefore influence the success of entire year classes of fish.

Christine M. Mayer and David H. Wahl, Center for Aquatic Ecology

New Exotic Insect Pest of Illinois Pines

In July 1992 nursery inspectors discovered a peculiar beetle damaging the fresh shoots of pines in a Christmas tree plantation near Cleveland, Ohio. Specimens of these beetles were submitted to specialists from the Animal and Plant Health Inspection Service (APHIS) of the U.S. Department of Agriculture who eventually identified them as the larger pine shoot beetle (*Tomicus piniperda*), a serious pest of pines in Europe. Alerted by APHIS officials, state and federal agencies began conducting surveys of pines throughout the Great Lakes region and were both surprised and alarmed to discover infestations of this exotic pest in pines not only in Ohio, where it was first discovered, but also in Pennsylvania, New York, Michigan, Indiana, and several counties in northeastern Illinois. A federal quarantine restricting the movement of Christmas trees, nursery stock, and any pine lumber with intact bark was imposed by November 1992 to attempt to prevent the spread of this new pest into major pine production areas.

Photo by James E. Appleby Dept. of Forestry, University of Illinois

Cross-section of a Scotch pine branch infested with the larger pine shoot beetle.

Illinois counties quarantined for pine shoot beetles. (Map, courtesy of Charles G. Helm, INHS Center for Economic Entomology)

Since its discovery in Ohio, Illinois Natural History Survey researchers have been cooperating with Illinois Department of Agriculture nursery inspectors and federal Plant Protection and Quarantine officials to determine the extent of pine shoot beetle distribution throughout the state and to assess the potential impact beetles might have on Illinois pines. Like all bark beetles, the pine shoot beetle breeds and lays its eggs in a system of tunnels, or galleries, beneath the bark of recently cut logs and stumps, or in dying pine trees. Larvae hatch and feed under the bark from April to June, then tunnel out of their feeding galleries as new adults from July through October. As the name implies, newly emerged adults are attracted to fresh shoots of healthy pines. The beetles bore into the center of this new growth and tunnel toward the shoot tip. Affected shoots droop, turn yellow, and may fall from the tree. Although adult beetles are only 3 to 5 mm long (about the size of a match head), they have the potential to remove large quantities of foliage when their populations are high, thereby affecting both the height and diameter of trees. Fortunately, shoot damage is presently causing only minor injury to trees in Illinois. After a summer of feeding within pine shoots, adult beetles leave the shoots and move inside the thick bark at the base of pines to spend the winter. Overwintered beetles leave these protected sites in early spring, lay their eggs, and begin the cycle again. These same adults may again move into pine shoots before they expire in the spring. Therefore, there is the possibility of a single generation damaging pine shoots twice.

The current infestations of pine shoot beetles are thought to have arrived from Europe in wood dunnage used to stabilize cargo on trans-oceanic ships since this pest has previously been intercepted in such materials at U.S. ports of entry. Because the pine shoot beetle was able to become established in the northeastern U.S. with such apparent ease, researchers began to question whether other foreign bark beetles might also become established without their knowledge.

The pine shoot beetle was the only exotic species detected during the 1994 survey, resulting in three new pine shoot beetle infested counties. Illinois now has ten infested and quarantined counties. Most of the beetle finds have been at Christmas tree farms, pine plantations, or nurseries. Although "quarantine" may have ominous connotations for some, those purchasing Christmas trees need not be alarmed or concerned that this beetle is harmful to humans or households in any way. On the other hand, commercial growers unable to ship trees because of quarantine restrictions, have certainly faced hardship as a result of this new pest that behaves like the Christmas grinch.

Charles G. Helm and John E. Lloyd, Center for Economic Entomology

Effects of Hydrology and Water Chemistry On Wetland Vegetation Zones

Survey staff working with Richard Cahill of the Illinois State Geological Survey and Douglas Shaw of the University of Illinois Department of Civil Engineering are monitoring relatively undisturbed representatives of several emergent wetland types (marshes, sedge meadows, and wet prairies) including Grass Lake Marsh, Wadsworth Prairie, West Chicago Prairie, and Collison Marsh.

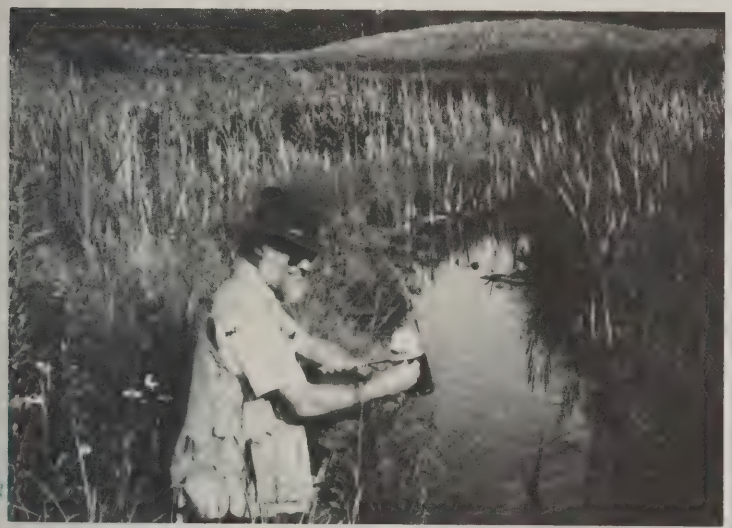


Photo by Scott Simon, INHS Center for Wildlife Ecology

The researchers are studying the influence of hydrology and water chemistry on vegetation zonation in these wetland communities. The studies will provide useful baseline information for evaluating changes within the communities sampled over time, for creating models for wetland restorations, and for evaluating natural fluctuations within the wetland system when making management decisions.

Emergent wetland communities include marshes, sedge meadows, wet prairies, seeps, and fens. Plant species in most undisturbed, emergent wetland communities assemble into zones in response to subtle differences in the water levels and water chemistry at a site. For example, plants such as hardstem bulrush, bur-reed, and arrowhead are usually found in deeper water than marsh milkweed, tussock sedge, and prairie cordgrass. Other plants such as angelica and grass-of-Parnassus are found in more mineral-rich water than fowl manna grass and Joe-Pye-weed. Because rainfall in Illinois is extremely variable, water levels (hydrology) and water chemistry vary over seasons and years in natural, undisturbed wetlands. Consequently, these vegetation zones may move from year to year in response to changes in hydrology and water chemistry.

Natural areas managers, attempting to protect these communities and the species that inhabit them, must be able to identify threats to community structure and diversity, and manage the community appropriately. Ecologists attempting to restore wet prairie and sedge meadow communities must have information about the presence and abundance of characteristic plant species, water levels over time (hydroperiods), and water chemistry profiles and variation in order to set goals and success criteria. The wetland manager or restorationist is often making decisions without adequate information about the hydrology, water chemistry, and vegetation for natural emergent wetland systems.

Photo by Scott Simon, INHS Center for Wildlife Ecology

Marsh Phlox

Researchers found dramatic differences in the vegetation components of various zones within emergent communities, based on water level changes of only a few inches. Water chemistry at many of the sites, including the permanently groundwater-fed seeps, varies seasonally and geographically. For example, sodium levels were higher for sites in the northern portion of the state, whereas sulfates were higher for sites in the central portion of the state. Levels of some water chemistry parameters (sulfate, phosphorus, and nitrate) were higher than current general-use water quality guidelines. These guidelines are sometimes used as standards for wetland mitigation projects.

Scott Simon and Marilyn Morris, Center for Wildlife Ecology, Dan Schneider, Center for Aquatic Ecology

Species Spotlight

Praying Mantis

Susan Post

During May the warm spring temperatures coax developing praying mantis eggs in their papier mache-like egg cases to hatch. The young, looking like miniature adults, wriggle out and hang head downward on a silken thread. Baby mantids are honey yellow in color, about the size of a mosquito, and voraciously hungry! There is no sibling bonding here, brother or sister is likely to become a first meal. For each 1,000 mantids that hatch, entomologists estimate that only two will survive to become an adult.

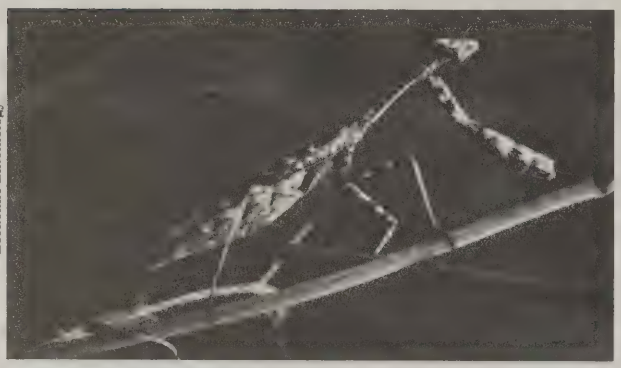


Photo by Michael Jeffords, INHS Center for Economic Entomology

Don't be fooled by the Praying Mantis' spiritual pose, it is probably more ready to attack than pray.

Illinois has one species of native praying mantis, *Stagomantis carolina*, the Carolina mantis. Found in the southern two-thirds of the state, it is about 2 inches long and variable in color. The mantis most people encounter, however, is the introduced Chinese mantis, measuring at least 3 inches long and brown or green in color.

Praying mantids have slender elongated bodies, with strong hind legs. The prothorax, the first thoracic segment, is long and tubelike. The front legs, found on the prothorax, are long, equipped with spines, and are habitually folded like hands in prayer. Mantids have a triangular face with two bulging compound eyes and a free swiveling head. These are the only insects that are able to look from side-to-side and over their shoulder.

Mantids are masters of camouflage. The Carolina mantids are grey-black, brown, or green, allowing them to resemble tree bark, grass stems, or twigs. These colors and patterns enable them to blend with the natural surroundings and make themselves harder to see for both their insect prey and their enemies, such as birds.

The ability to hang motionless for hours at a time with its forelegs clasped and held out like the arms of a praying monk, inspired the common name praying mantis. The name "preying" mantis would be more fitting as the insect is not waiting for inspiration from above, but insect prey to satisfy its hunger—even when it is stuffed it waits for more. From the moment of hatching, mantids are carnivorous and ready to battle with most any insect foe. Mantid prey includes grasshoppers, crickets, beetles, bumblebees, wasps, and even other mantids. The mantis grasps prey in a deadly embrace with its heavily spined forelegs, uses its mandibles to cut into the flesh, and then eats the "victim" alive.

Mantids overwinter as eggs, hatch in the spring, and spend the summer eating and growing. In early autumn they mate and the female hangs head downward on a weed stem or twig and deposits two hundred or more eggs inside a frothy mass that soon hardens into a tough waterproof egg case. This egg case is called an ootheca and acts like insulation to protect the eggs throughout the winter.

Teacher's Guide to "The Naturalist's Apprentice" (facing page)

Objective: students learn some of the diverse places insects lay their eggs to reproduce

Materials: multiple copies of **Where the Eggs Are**

Vocabulary: reproduction, nurture, complete metamorphosis, incomplete metamorphosis

Comments: The modes of insect reproduction are nearly as numerous as the kinds of insects that exist on earth. In this issue of *The Naturalist's Apprentice* we explore egg-laying and the way a few insects treat their young. Parental care in insects ranges from nonexistent (walking sticks merely drop their eggs to the ground while walking along) to a high level of nurturing (bees and wasps have a highly developed social structure and adults feed young until they are grown). Along the way we find insects whose young are cared for by parents for awhile, but if they stay around too long, they may become a meal for a parent (earwigs), or other species that produce live young that stay near the mother, soon reproduce themselves, and eventually form large colonies (the aphids). In general, if the mind can conceive of a method of reproduction, the insects have likely incorporated it into some bizarre and wonderful life style, somewhere on earth.

Procedure:

1. Introduce the subject of insect reproduction/egg laying by using the examples given in the comments section and in *Species Spotlight.*
2. Distribute copies of **Where the Eggs Are** and have students match the description in column 1 (next page) with the correct egg picture in column two with the correct adult picture in column three. *Answers: A-5-V, B-3-Y, C-4-X, D-2-Z, E-1-W*
3. Have students list other places where they think insects might lay their eggs. What food would these newly hatched insects likely feed on? Which insects in the exercise have incomplete metamorphosis; complete metamorphosis?

Study the three columns below and choose one item from each column to form a complete description of various types of egg-laying insect behaviors.

Column 1

A. I lay my eggs in the soil in a group called a pod. My close relatives, the katydids, usually lay their eggs in a slit in a plant stem.

B. My eggs are protected from most predators that happen along with a hungry stomach. When I'm grown, I have lacy wings and long antennae.

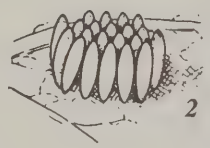
C. When my babies hatch they eat the insides of other insects. I put my eggs where the babies can find an easy meal. My relatives are ants and bees.

D. My young must search for their food, so I lay my eggs close together on a plant where they can find their favorite food, the aphid. I belong to the largest group of insects, the beetles.

E. I drop my eggs wherever I may be. I do put them in a nice, neat package, though, like my relative the praying mantis.

Column 2

1



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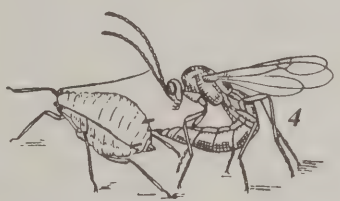

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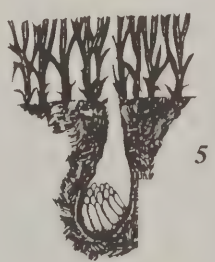

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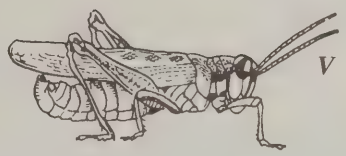
Column 3



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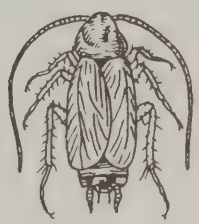

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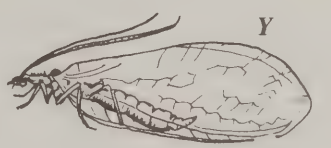

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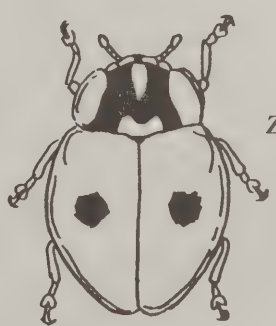

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Fingerprinting Bacteria

The bacterium *Bacillus thuringiensis*, subspecies *israelensis*, is the only microbial insecticide registered in Illinois for use against mosquitoes which utilize waste tires as larval habitat. This bacterium is commonly referred to as "Bti." Bti produces a protein crystal that is toxic to larval mosquitoes when ingested, but is harmless to nontarget insects, fish, birds, and mammals. The Medical Entomology Program is interested in determining if there are native strains of Bti in Illinois, and if so, determining their distribution within the state. The answer to this question is complicated by the widespread use of Bti within Illinois by Mosquito Abatement Districts as well as individuals. If we recover Bti from mosquito habitat, how do we know that it wasn't sprayed there by man? The answer to this last question lies in the composition of the envelope surrounding the bacterial cell.

Using a technique know as "gas liquid chromatography" (GLC), in collaboration with Dr. A. Ray Smith of the UI's Department of Veterinary Pathobiology, we concentrate on major building blocks of the cell envelope — fatty acids. GLC enables us to identify both the fatty acids that comprise the cell envelope, as well as their percent composition. Each strain of *Bacillus thuringiensis* has a unique pattern, analogous to a fingerprint, which we refer to as a profile. Profiles can be compared by a variety of statistical techniques. Consequently, when we recover Bti in the field, we can compare it to our library of commercial products and determine if it is a native strain. To date, we have discovered seven strains of Bti native to Illinois that are toxic to the following vector species: *Aedes aegypti, Aedes albopictus, Aedes triseriatus, Culex pipiens*, and *Culex quinquefasciatus*. These discoveries have come from material collected from flood plains and waste tires. In fact, waste tires appear to be excellent collectors of *Bacillus thuringiensis,* perhaps because bacterial spores settle into tires from the air, or the spores are present in dirt deposited within tires.

In the next phase of our research, we will concentrate on whether the presence of native strains of Bti within a tire affect the ability of mosquitoes, which serve as vectors for human and animal diseases, to become established. As a secondary benefit, our profiles will help us determine the usage pattern of commercially produced Bti within Illinois, as well as its persistence. Information of this nature is essential to answer the seemingly simple question of why mosquitoes are present in tire A and not tire B, when both tires seem identical to us. As a sidelight, we can identify the three subspecies of *Bacillus thuringiensis* used in agriculture and determine their persistence in the environment, as well.

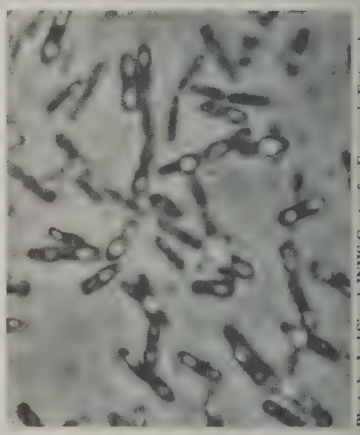

Photo by Joel Siegel, INHS Center for Economic Entomology

Bacillus thuringiensis (Bti) at 1000X (oil immersion lens), using phase contrast illumination

Joel P. Siegel and Robert J. Novak, Medical Entomology Program, Center for Economic Entomology, Illinois Natural History Survey,
A. Ray Smith, Department of Veterinary Pathobiology, College of Veterinary Medicine, University of Illinois at Urbana-Champaign

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INSIDE

Human Noise and Wildlife

Noise is an especially pervasive by-product of human civilization, one that has the ability to spread into natural areas and influence animals at a distance.

Anyone accustomed to the outdoors knows how quiet one must be to be able to see some wary kinds of animals. One can imagine how the sound of gunshots might affect a coyote. However, anecdotal accounts abound of wild animals that are tolerant of human noises; for example, deer that barely look up as commercial airliners roar close overhead and birds that breed so close to blast noise that their nests bob about in the pressure waves.

Noise can affect animals in many ways, including interfering with their hearing of predators or prey, disrupting their vocal communication, and causing more vaguely defined changes such as "stress" or avoidance of a noisy area. In the case of extremely loud noise, animals' hearing may be temporarily affected or permanently damaged.

The scientific evidence addressing the issues of human noise and wildlife is still rather meager, but some interesting research has been performed. Field censuses have compared areas near roads with areas selected to be as similar as possible but farther (over 300 yards) from roads. Many species were found in significantly lower numbers in the plots close to roads. Unfortunately, we do not yet know the mechanism for this effect. Possibilities include noise, sight of vehicles, smell, perhaps even fewer available insects.

Photo courtesy Illinois Department of Conservation

Deer browsing next to a tollway near Chicago.

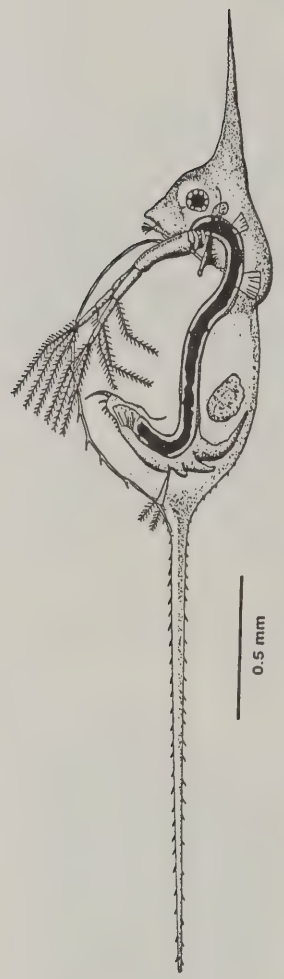
In other experiments, anurans (frogs and toads) living near highway noise could not determine the direction of sound sources as well as those living in quieter places. The males near highways altered their calling and spaced themselves differently when attempting to attract females. We obtained similar results by playing recorded highway noise from loudspeakers. We verified that it was the noise generated by the highway traffic and not other kinds of pollution or indirect causes that affected the anurans.

As in much ecological research, our study of the effects of human noise on wildlife has ranged into many disciplines, including acoustics, the psychology of hearing, medical aspects of hearing loss, animal husbandry, and modern wildlife biology. We have collected and summarized scientific articles pertaining to noise effects on wildlife.

This research is sponsored by the U.S. Army Construction Engineering Research Laboratories because the U.S. military is responsible for about 12 million acres of land, including critical habitat for hard-pressed wildlife species. Many sources of military noise, such as small-arms fire, off-road and other vehicle traffic, and helicopters, are comparable to noise found almost anywhere in Illinois.

Ronald P. Larkin, Center for Wildlife Ecology

An Exotic Zooplankton in Illinois



Daphnia lumholtzi. (Drawing provided courtesy of "Oceanography and Limnology.")

The zooplankton species *Daphnia lumholtzi*, which is native to Africa, Australia, and southern Asia, has been discovered in central Illinois impoundments by Natural History Survey researchers. The species was first found by Survey staff in Lake Springfield in 1992, and by late summer 1993, *D. lumholtzi* was the most abundant large zooplankton species in that lake. In 1994, the foreign zooplankton also was discovered in Lake Decatur, Clinton Lake, Sangchris Lake, and Lake Taylorville.

Zooplankton are microscopic animals that form the base of the food chain for many aquatic animals. Because zooplankton are a vital food supply for many newly hatched and even adult fish, the introduction of *D. lumholtzi* may negatively affect the fish communities of the waters it infests.

Daphnia lumholtzi is very different from other zooplankton found in Illinois. It is longer and has large spines on the head and tail. Including spine lengths, *D. lumholtzi* reaches almost 6 mm. Newly hatched fish consume a great deal of zooplankton, but they typically do not consume zooplankton exceeding 2 mm due to mouth size limitations. Because of their larger mouth size, juvenile and adult fish may more easily consume *D. lumholtzi* and, in fact, they may actually prefer them over smaller native zooplankton.

The first discovery of *D. lumholtzi* in the United States was in a Texas impoundment in 1991. Researchers speculate that the species was accidentally introduced when two fish species, Nile perch and *tiliapa*, both obtained from Africa, were stocked into the reservoir. Since 1991, *D. lumholtzi* has spread at an alarming rate over a large portion of the southeastern United States. In addition to Illinois, it is currently found in Texas, Missouri, Tennessee, and North Carolina.

To date, all waters in Illinois found infested with the foreign zooplankton have been impoundments. Discharge leaving impoundments over spillways may further the spread of *D. lumholtzi*.

To determine possible early effects of *D. lumholtzi* in Lake Springfield, Survey staff compared the zooplankton community of Lake Springfield in 1992 and 1993 to those of Pierce Lake and Lake George in northern Illinois during the same time period. They found that while the zooplankton communities in Pierce Lake and Lake George in 1992 were similar to the 1993 communities, there was a dramatic decline in all types of native zooplankton in Lake Springfield from 1992 to1993. *Daphnia lumholtzi* increased in abundance during the same time period.

Unlike zooplankton native to Illinois, which are abundant in April and May, *D. lumholtzi* was found in highest abundance (2.6/L) as water temperature peaked in late July 1993. Because the foreign species is native to warmer climes, it is assumed that it is better adapted to warmer temperatures than native zooplankton species.

If the extensive head and tail spines of *D. lumholtzi* deter fish predation, the species could lead to a major restructuring of the zooplankton community. Initial research at Lake Springfield suggests that this may be occurring, but additional data are needed before a definite conclusion can be made. The dramatic decline in zooplankton in Lake Springfield between 1992 and 1993 may be due in part to the invasion of *D. lumholtzi*. The relatively low number of the species (2.6/L) in 1993 seems insufficient to cause the decline. But there are numerous ways that an exotic species might have negative effects, hence a large population of *D. lumholtzi* may not be necessary to have an effect on the zooplankton community.

In general, exotic species like *D. lumholtzi* lack natural biological controls such as predators, competitors, and parasites that are found in their native environments. As a result, there can be shifts in food webs, economic losses, and the extinction or extirpation of native species. However, if fish consume *D. lumholtzi*, the foreign zooplankton may provide an abundant food source for planktivorous fish during late summer when the abundance of other zooplankton is low. Given the unpredictable effects of the addition of *D. lumholtzi* to the aquatic communities of Illinois, further study of this exotic is necessary.

Cynthia S. Kolar, James C. Boase, and David H. Wahl, Center for Aquatic Ecology.

Long-term Monitoring of Freshwater Mussels

The freshwater mussel fauna of North America has undergone an alarming decline over the past century. The geographic range of most species has decreased significantly, many species face extinction, and the entire fauna appears to be declining. Concern for this declining resource led federal and state governments to enact endangered species legislation. In addition to the protection afforded these rare species, state and federal conservation agencies have recommended that significant mussel populations be protected. The most effective way to protect these sensitive species is to preserve their habitat. However, in the face of growing urbanization, localized impacts (such as the building of bridges) on the fauna appear unavoidable.

In 1987, the Washington Avenue bridge in Kankakee was scheduled for demolition and replacement. Preliminary surveys by INHS staff at the bridge site revealed one of the richest mussel beds in the Kankakee River. We developed a plan to relocate all mussels in the vicinity of the bridge and to monitor these populations over time. Our objectives were to evaluate growth, movement, and mortality over the long term. The purpose of this monitoring, supported by the Illinois Department of Transportation, was to assess the effectiveness of mussel relocation as an acceptable mitigation strategy.

The first phase of the project involved moving over 4,000 mussels, representing 20 species, from the bridge site. This was accomplished in 1987 under the direction of INHS biologists Jeanine Berlocher and Mark Wetzel. Live mussels were collected, identified, weighed, and measured, and a sequential number was etched into each shell. Mussels were then transported to sites upstream and placed into a series of plots. The transplant sites had been chosen previously because they had water depth and substrate similar to those of the bridge site. Mussels that already occurred in these locations were also marked so that the existing (controls) and new (relocatees) populations could be compared over time.

The next phase of the plan involved monitoring the mussel populations on a regular basis.

Photo by Mark Wetzel, INHS Center for Biodiversity

Survey staff monitoring mussels in the Kankakee River.

Transplant sites were visited in 1988, 1989, 1991, and 1994. A subsample of the plots was checked both inside and outside the delineated areas. The locations of recovered mussels were noted, all live mussels were weighed and measured, and all dead shells were collected.

An initial assessment of mussel survival indicated there was no observed mortality resulting from handling or transporting to the sites. The percentage of dead marked shell recovered from the plots over time was used as a general indication of mortality. Although not accurate, this amount was used to compare mortality of relocatees with that of controls at a location. After 1 year, approximately 7% of the individuals recovered was from marked dead shell. This

Continued on page 5

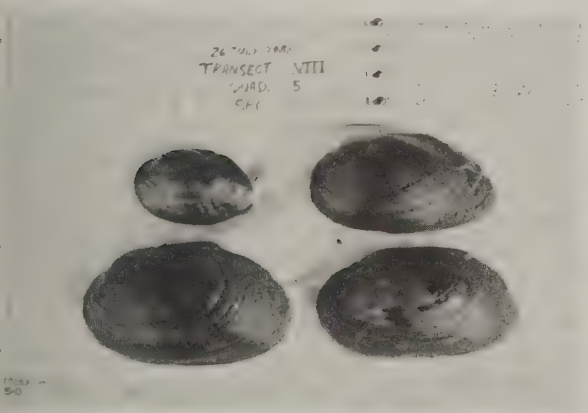


Photo by Mark Wetzel, INHS Center for Biodiversity

Mussel samples from monitoring project.

Habitat Partitioning by Therevids at Sand Ridge State Forest

If you were a ground-dwelling insect larva, one of your greatest fears would be to meet up with a stiletto fly larva (family *Therevidae*). These small, snakelike predators swim through sandy soils in search of food. They devour any insect larva they encounter, including other therevids. Because of their voracious appetites, the stiletto fly larvae impact populations of many root-feeding arthropods in a major way. Their biodiversity may be useful as an ecological indicator because fluctuations in therevid populations coincide with fluctuations in the populations of the many arthropods on which they feed. They are also potential biological control agents of agricultural pests such as corn rootworms in sandy soils.

Photo by Gail Kampmeier, INHS Center for Economic Entomology

INHS researcher Marianne Hartman checks a malaise trap at Sand Ridge State Forest.

We are studying the bioecology of therevids at Sand Ridge State Forest in Mason County, Illinois, where several species of adult therevids have been found. Nothing is known about how the larvae of different species coexist in such a habitat. Without some method of isolating therevid species, all of which are general predators, the better-adapted species would likely eliminate others by outcompeting them for food. The researchers on this project hypothesized that adult females of the various species lay their eggs in different microhabitats and the larvae develop at different times of the season, thus reducing potential interspecific competition.

More than 200 emergence traps were set out at Sand Ridge State Forest to test some aspects of this hypothesis. The emergence traps, made from upside-down buckets with an opening covered by a funnel and collecting cup, were placed randomly along 300 meters of a trail. Therevids in the sandy substrate beneath the traps were caught when they matured to adulthood and flew. Soil type, shadiness, ground cover, and vegetation were described around each emergence trap to depict the microhabitats of the traps. Two malaise traps (5 m long tent-like screens with poison collecting cylinders at either end) captured adult flies as they flew through the forest or along the trail. The malaise and emergence traps were checked for therevids once a week during the summers of 1992 and 1993.

The trail along which the traps were placed divided the area into two major habitats: natural and managed forest types. An undisturbed oak-hickory forest existed north of the trail, and a planted pine forest was located south of the trail. By looking for differences in therevid populations between the two forest types, we thought it would be possible to assess how replacing a natural with a managed forest affects populations of root-feeding arthropods.

The malaise traps captured nearly 400 therevids in 1992 and 100 in 1993. The emergence traps collected 75 and 150 therevids in 1992 and 1993, respectively. In total, some 6 species in 4 genera of therevids were trapped in malaise traps, while only 5 species in 3 genera were found in the emergence traps. The absence of 1 species from the emergence traps is an indication of habitat partitioning. This species apparently develops in a habitat out of the range of the emergence traps.

There was no obvious correlation between any therevid species and a microhabitat, and all 5 species of therevids from emergence traps occurred in each habitat type. In addition, populations of all species peaked at the same time; 2 species peaked twice and 3 species peaked once each

Continued on page 5

Monitoring Mussels

continued from page 3

percentage has been amazingly consistent over time, varying by only 1 to 2 % in 7 years.

Individual mussel growth, as measured by increased shell length and width, was evaluated over time. As might be expected, smaller individuals grew substantially, but larger mussels did not appear to grow much annually. Comparisons between 1987 and 1994, however, demonstrated growth even in very old individuals. Overall, moving mussels did not appear to reduce or arrest their growth.

Percent recovery of marked mussels declined with each subsequent year. After the first year, overall recovery was estimated at 57%, varying from 24% to 79% between plots. Seven years later a recovery rate of only 5.6% was estimated. These rates were based on recovery of individuals found in subsamples from both inside and outside the plots. Loss of mussels may be a result of upstream, lateral, or downstream movement, which may also account for the origin of unmarked mussels collected in the plots.

This project offers evidence that mussels will survive and grow after being relocated. Low recovery of individuals may be a function of normal downstream attrition, a highly mobile mussel community, or mortality with shells swept far away from the site. Even with low recovery rates, relocation as a mitigation measure may be used to reduce the damage to mussel communities from localized site impacts. Although strategies to protect mussel populations have not been clearly formulated, mussel transplants may be a reasonable conservation strategy to assist mussel populations if specific threats to the fauna are imminent.

Helen Elise Kitchel, Center for Biodiversity

Therevids

continued from page 4

season. All species were present in the first population peak, which occurred in late May to early June. The two most numerous species then peaked again in late July and early August. Separate population peaks would indicate that therevids were reducing competition by developing at different times. The data also suggest that some species may produce 2 generations per year. Until now, therevids have all been thought to produce a single generation per year. Perhaps these therevids overwinter as last instar larvae and emerge as adults in May. The eggs resulting from this generation would hatch and the larvae would develop rapidly during June and July when insect larvae are most abundant in the sandy substrate and when temperatures are warm.

The researchers found no apparent differences between the therevid populations in the natural and managed forests. It is unclear from this finding whether differences in species composition and population density occur in the root-feeding insect populations of the two forest types. Because therevids are generalist predators, they can survive on a variety of food resources.

We found that therevids have a dramatically skewed sex ratio. Approximately 85 percent of the therevids caught were females. This ratio was consistent for many of the more abundantly collected species. The males were caught slightly earlier than the females, indicating that they emerge earlier and mate when the females emerge. In this way they ensure that females will be mated, even though there are many more females than males.

There is much to learn about the bioecology of these flies. Their important roles in ecosystem dynamics and their potential as biological control agents strongly suggest that further investigations are warranted. The authors wish to thank John Taft and Rick Phillippe at the Illinois Natural History Survey's Center for Biodiversity; the rangers at Sand Ridge State Forest, Dan Riggs and John Meredith; and the Illinois Department of Conservation for their assistance in this study.

Marianne Hartman, Michael Irwin, and Gail Kampmeier, Center for Economic Entomology

Photo by Gail Kampmeier, INHS Center for Economic Entomology

Example of an emergence trap used in the therevid study.

Species Spotlight

Pitcher Plants

Susan Post

The pitcher plant, *Sarracenia purpurea*, has turned the tables on animals—eating them rather than being eaten. Pitcher plants are classified as carnivorous rather than insectivorous because they consume not only insects but also isopods, mites, spiders, and an occasional small frog. While carnivory helps the plants remain vigorous, grow larger, and produce more flowers, it does not appear essential for the survival of individual plants. This unusual life-style has evolved as a means of obtaining nutrients in places otherwise deficient in them. In addition to phosphorus and nitrogen, pitcher plants obtain vitamins and other trace minerals from their prey.

Photo by Michael Jeffords, INHS Center for Economic Entomology

A pitcher plant patiently awaiting its next meal.

Pitcher plants have a rosette of tubular-shaped green leaves streaked with purple and red. In June, nodding umbrella-shaped maroon flowers appear on a stalk 1 to 2 feet above the plants. When closed, the flowers resemble apples on a stick. Listed as an endangered species in Illinois, pitcher plants are found in bogs, fens, and on calcareous floating mats—habitats that are found in the northeastern corner of Illinois, where they are rare.

The leaves of the pitcher plant are not flat like those of most plants; they have become highly specialized, having evolved a passive way to catch prey — a pitfall trap. The leaf edges have curled around and fused to form a liquid-holding vessel, similar in shape to a cornucopia. The leaves grow from a basal rosette and a "keel" provides structural reinforcement to each leaf so that the opening is always upright. The modified leaves perform the task of taking in nutrients required for photosynthesis. Insects are attracted to the colorful leaf rosettes that resemble flowers; the red lip of the "pitcher" is particularly attractive as a landing zone. Red veins that lead downward are baited with nectar. While following this lure, prey reach the curve of the tube, which is lined with fine hairs, all pointing downward. A slip and the animal is soon speeding to its impending doom. It plummets into the pitcher, which contains rain, dew, and a digestive enzyme that soon dissolves the victim.

Root systems of carnivorous plants tend to be weak and poorly developed. Since the roots function almost entirely as support, the highly acidic bog water doesn't seem to bother them.

Habitat destruction and illicit collecting are the biggest threats to the survival of the endangered pitcher plant in Illinois.

Teacher's Guide to "The Naturalist's Apprentice" (facing page)

OBJECTIVE: students learn some of the devious ways plants and animals catch their prey

MATERIALS: multiple copies of **Traps and Snares** cut apart

VOCABULARY: carnivorous, predaceous

COMMENTS: Some organisms resort to guile and deceit and create all manner of traps, snares, and ambush sites to help them catch their next meal. *Ant lion* larvae dig a funnel-shaped trap in sand and wait at the bottom for unsuspecting prey to tumble in where they are pierced with long, slender jaws. *Orb weaver spiders* build spiral webs of silk that entangle passing insects. One group of *caddisfly* larvae construct silken nets underwater that trap food particles. *Fishing spiders* feed mostly on small animals (although they will catch small fish) that fall in the water and become trapped in the surface film. They use the surface film of water as a web. The *trapdoor spider* builds a silk-lined burrow with a close-fitting lid. When it feels the vibrations of approaching prey, the spider jumps out, grabs its prey, and drags it into the burrow.

PROCEDURE:

1. Introduce students to the material in *Species Spotlight* and the preceding comments section. Challenge them to remember what kinds of organisms use various types of traps and snares. Divide the class into several smaller groups of 5 or 6 each.
2. Copy the following page onto card stock (you may also glue the page to cardboard) and cut apart the paired cards. You will need one set of cards for each group.
3. Pass out the cards from the left-hand column (the organisms) and have each group try to identify that organism based on the descriptions you provide. Students then place the organism cards face down on a table while you pass out the snare/trap cards (right-hand column). Students do not look at these but place them face down with the organism cards and mix the sets together.
4. The first player in each group turns up two cards, tries to identify each card, and states whether the cards are a match. A match consists of an organism and its appropriate snare or trap. Students that correctly identify a match take those two cards from the desk top and play proceeds to the next student. If a match is not made, students place the cards face down on the table and play proceeds. The player with the most cards when all have been matched is judged the winner.

Forbes Biological Station Begins Second Century of Research

The Illinois Natural History Survey's Forbes Biological Station on the Illinois River at Havana has begun its second century of research. The station was officially opened on 1 April 1894 by Dr. Stephen A. Forbes, founding chief of the Survey. It was the first inland aquatic biological station in the country manned and equipped for continuous investigations, and the first to dedicate itself to the study of a major river system.

Forbes selected Havana as the site because the river's bluffs and beaches and the abundance of pure spring water provided good working and camping conditions for field researchers. Initially established with a $1,800 appropriation from the state legislature, the first station consisted of three rented rooms in Havana, a 120-volume library, and a chartered cabin boat moored on Quiver Lake.

With additional funds in 1895, a 60-ft houseboat that was to serve as a floating laboratory was built in Havana from plans drawn under Forbes' direction. The boat, which was ready in September 1896, gave the station the advantage of mobility and year-round operation.

In 1903, Forbes noted that over 6,000 collections of fishes, plankton, and a variety of aquatic forms had been made since the station's opening. Weekly water samples had been analyzed for a consecutive period of 3 1/2 years. In addition to local collections, boatside samples had been taken along 450 miles of the Illinois River and 316 miles of the Mississippi River.

Continuous collections at the biological station made possible the first edition of *The Fishes of Illinois* in 1908. This book, a joint endeavor by Forbes and Survey aquatic biologist Robert E. Richardson, was issued in a second edition in 1920 and remained a unique publication for more than 40 years.

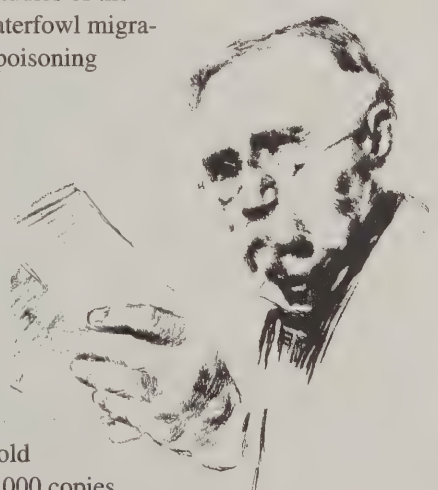
Wildlife research at the Survey began in the 1870s when Forbes investigated the food habits of birds. Not until 1938, however, was wildlife research fully recognized in the Survey's program when Arthur S. Hawkins and Frank C. Bellrose were employed to initiate a waterfowl research program. The first permanent structure for the field station was completed on Lake Chautauqua in early 1940, and Hawkins, Bellrose, and John M. "Frosty" Anderson moved into the new building to begin what would become one of the most productive waterfowl research programs ever conducted at the field station. Several benchmark studies in the biology of waterfowl were produced that did much to advance the art of waterfowl management.

The Survey's program to band waterfowl begun by "Frosty" Anderson in 1939 expanded rapidly and continued through 1952. Over 75,000 ducks, mostly mallards, were banded during this time, generating important information such as migration behavior. Following extensive die-offs of mallards in 1947 and 1948, the Survey began an investigation of the effects of lead shot on waterfowl that was to span a period of more than 40 years. This and subsequent studies at the station were instrumental in developing a federal program implemented nationwide in 1991 for eliminating lead shot for waterfowl hunting.

Photo from INHS image archives.

Forbes Biological Station as seen from Quiver Creek.

Bellrose's studies of the wood duck, waterfowl migration, and lead poisoning are considered landmarks in the field. His publication of *Ducks, Geese and Swans of North America*, an updated edition of a 1942 classic, sold more than 300,000 copies and was recognized by the Wildlife Society as the best book publication of 1977.



Stephen A. Forbes, namesake of Forbes Biological Station.

Continued on next page

Corn Rootworm Injury: Reducing Prophylactic Soil Insecticide Treatments

The environmental and economic benefits of reducing the dependence of farmers on soil-applied corn rootworm insecticides are numerous.

Photo from INHS image archives

Corn roots injured by rootworms.

Although soil insecticides don't leach as readily as many of the commonly used herbicides, these products have the potential to contaminate surface and ground water resources, especially in the spring if planting is followed by heavy precipitation.

Illinois corn producers grow an estimated 2.8 million acres of continuous corn (corn grown in the same location year after year with no crop rotation). Approximately 2.5 million acres (88 percent) are treated with a soil insecticide each spring during planting. The great majority of the acreage is treated in a prophylactic fashion — pesticides are applied without first examining acreage to determine if rootworms are present in sufficient numbers to warrant application. The estimated expense to Illinois farmers for soil insecticide applied during planting for corn rootworms is $26.5 million. Based on on-farm investigations in 1990 and 1991, it was discovered that as many as half of the growers would not have required an insecticide treatment based on the level of root injury observed on their farms.

If the majority of producers in Illinois were aware of and could select tolerant varieties of corn instead of using a soil insecticide, the economic ($26.5 million saved), environmental (reduction of the threat to nontarget organisms), and personal health and safety benefits would be substantial. Virtually no contemporary information is available regarding the ability of corn hybrids to compensate for rootworm injury. Kevin Steffey, an entomologist with the Illinois Natural History Survey, demonstrated that a hybrid used in a University of Illinois trial was able to respond to rootworm injury by regrowing new root tissue. When yields were measured, no meaningful differences were observed among treatments despite the wide range of root injury found. In 1993, a hybrid evaluation experiment was conducted near DeKalb, Illinois. Results from this study have thus far shown that hybrids don't always respond in precisely the manner anticipated. For instance, one hybrid that had the largest root volume had the lowest yield. Conversely, the three top yielding hybrids had the smallest root volumes. Our preliminary data suggest that some hybrids expend resources growing new roots in response to rootworm injury rather than increasing grain yield. The interactions among rootworms, corn plants, and environmental conditions are complex and additional research is required in order to attempt to clarify these relationships.

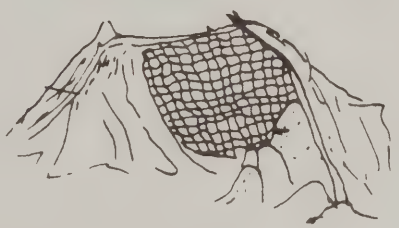
A great deal of interest is currently being focused on the granular formulation of soil insecticides. This concern is being triggered in part because of the Environmental Protection Agency's concern over avian safety in treated cornfields. In addition, with the current emphasis of the Clinton administration on reducing pesticide use, soil insecticides come under immediate scrutiny. Because of the renewed emphasis on seeking pesticide alternatives, identifying potential roles for host plant resistance is becoming more imperative. Obtaining knowledge about how corn plants respond to corn rootworm injury may aid in the development of resistant corn hybrids.

Michael E. Gray and Kevin L. Steffey, Center for Economic Entomology

Ant lion and pit

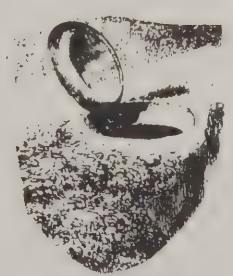
Orb weaver spider and web

Caddisfly larva and web



Fishing spider and water habitat

Trapdoor spider and burrow



"The Naturalist's Apprentice" presents educational activities for middle school students. Teachers are invited to photocopy this page for classroom use.

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Forbes Station

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Photo from INHS image archives.

Robert E. Richardson and assistant Henry C. Allen studying fish breeding grounds in 1910.

Illinois Natural History Survey Reports is published bimonthly by the Illinois Natural History Survey, 607 East Peabody Drive, Champaign, IL 61820. Headquartered on the campus of the University of Illinois at Urbana-Champaign, the Survey is a division of the Illinois Department of Energy and Natural Resources

INHS Reports is edited by Charlie Warwick and Tom Rice and printed on recycled paper. Design consulting is provided by Otto-Walker Communications.

Bellrose and his colleague, Dan Holm, collaborated on another book, *Ecology and Management of the Wood Duck.*

One of the best wildlife data sets ever compiled in North America had its genesis in 1938 when Bellrose censused waterfowl during the fall migration in the Illinois Valley. Ground counts were continued until the fall of 1948 when aerial censuses of the Illinois River floodplain were begun. These weekly aerial counts are still conducted. The massive amount of data provided by years of censusing has vastly improved our understanding of the chronology of migration, the effects of refuges, the value of wetlands, and the distribution of waterfowl in Illinois.

One of the most important studies implemented by Dr. William C. Starrett , director of the station from 1948 to 1972, was an annual electrofishing survey of the Illinois River. Begun in 1959, the survey continues to be updated and provides a baseline for documenting changes in number, distribution, and species of fish populations as the river system continually sustains changes brought about by natural processes and human activity.

Research at the station is currently directed by Dr. Stephen P. Havera and Dr. Richard E. Sparks. Sparks, an aquatic biologist at the station since 1972, has added to our understanding of the effects of chemical contaminants on aquatic organisms, soil erosion and sedimentation as factors in stream pollution, and the ecological impacts of barge-fleeting and river navigation.

Havera, who has been with the Survey since 1972, has served as director of the Havana station since 1982. He is a wildlife ecologist whose research interests include animal ecology, physiology, nutrition, and habitat relationships. Havera recently completed a book manuscript on a comprehensive study of waterfowl in Illinois.

In 1988, construction for an addition to the station was funded by a grant from the National Science Foundation and the Illinois Capital Development Board. The station, officially named the Stephen A. Forbes Biological Station in May 1989, has expanded to include a leased building in Havana and a staff of approximately 30 full- and part-time people.

The staff at Forbes Biological Station continues to work in three areas of demonstrated competence: river and wetland ecology, population studies of aquatic organisms and migratory birds, and toxicological and habitat studies. The researchers hope to make significant contributions to national and international issues such as the functions and values of wetlands, biodiversity, ecosystem management, and floodplain management and restoration.

A publication on the station, *Forbes Biological Station: The Past and the Promise*, is available upon request from the Illinois Natural History Survey, 607 E. Peabody, Champaign, IL 61820.

Stephen P. Havera and Katie E. Roat, Center for Wildlife Ecology

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NATURAL HISTORY SURVEY

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INSIDE

Nonresident Prairie Chickens in Illinois

Illinois' native prairie chickens numbered about 50 individuals in spring 1994. Only 5 or 6 remnant boomers (males) and an unknown number of hens remained in Jasper County, but at least 18 cocks and 7 hens persisted in Marion County. Later in summer 1994, we received unverified reports of prairie chickens on two separate farms enrolled in the Conservation Reserve Program in Marion County, so perhaps more birds are there than was thought.

Current numbers contrast with millions of prairie chickens found statewide in the mid to late 1800s when prairies gave way to agriculture. Dramatic population increases on sanctuary grasslands during the late 1960s to the mid-1980s were followed by dangerous downward trends in numbers. Decimating factors included intensified land use on private land near sanctuaries and intense interactions with pheasants (now under local control by Illinois Department of Conservation [IDOC] managers). Also, long-term (1963-91) declines in fertility and hatch rate of prairie chicken eggs may represent the classic symptoms of inbreeding depression. A 1992 action plan by IDOC for genetic management called for translocations from large populations to enhance genetic variability and numbers of Illinois prairie chickens. So far, three releases have been made and are now being evaluated.

Photo by Tom J. Ulrich, INHS Image Archives

A Prairie Chicken Boomer Strutting His Stuff

New residents in spring 1994 in Jasper County included at least 1 of 15 radio-marked Minnesota hens released in August 1992. Other hens with dead radios might have been present from the 1992 release. In 1993, the verified hen lost her brood (the only radioed brood in 1993) within 3 weeks after hatching, but she fledged young this year.

A second release of Minnesota origin included eight cocks and four hens (all radioed) in August 1993. Two of these cocks were successfully translocated as 5-week-old chicks with the brood hen; one of the two males became a dominant boomer in 1994.

The mother's nest was depredated on a sanctuary about 100 yards from her 1993 release site. Another hen from the four released in 1993 apparently fledged at least one chick this year.

Surprisingly, one Minnesota cock showed up in spring 1994 among booming grounds (courtship and mating sites) in Marion County some 40 miles from the 1993 release site in Jasper County.

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Dramatic population increases on sanctuary grasslands during the late 1960s to the mid-1980s were followed by dangerous downward trends in numbers.

North Central Regional Committee on the Biological Control of Arthropods

Several societal issues facing agriculture involve pest management. These include water, soil, and air contamination; food safety and consumer health; farm worker safety; and environmental and economic sustainability. Additional issues include reduction of pesticide efficacy through pest resistance and withdrawal of pesticide registrations.

Biological control is a safe and effective approach to pest control but it has not been developed adequately in the north central United States, especially compared to regions that have historical strength in implementation of biological controls.

Midwest Institute of Biological Control

Established in 1990 to address educational needs in biological control in the North Central Region, the Midwest Institute of Biological Control has conducted four workshops to date, offering supplemental biological control education to nearly 100 graduate students.

Courses:

- The Theories and Models of Biological Control, Purdue University, 1991: computer simulations and mathematical models were used to study the quantitative and theoretical aspects of biological control.
- Insect Pathology, University of Illinois, 1992: this workshop focused on the diseases of insects.
- Biology and Behavior of Entomophagus Species, Iowa State University, 1993: predators and parasitoids of pest insects were the focus of this workshop.
- Applied Biological Control, Michigan State University, 1994: students received training in the use of biological control agents in real-world settings.
- Insect Pathology and Biological Behavior of Entomophagus Species, University of Illinois, 1995: these two courses will be combined this summer in a week-long session.

In recent years there has been substantially increased interest in biological control in the North Central Region. Although there are many independent active research programs, much of the recent increased interest can be attributed to the activities of two regional committees, the North Central Regional Committee on the Biological Control of Arthropods (NCR-125), and an offshoot, the Ladybird Committee.

The USDA-CSRS (United States Department of Agriculture-Cooperative State Research Service) North Central Regional Committee on Biological Control was originally proposed in 1980 and approved in 1981. The committee's current charter is effective through September 1996. It is an informational committee, that receives funds for an annual meeting to exchange biological control information. The committee objectives are:

1) to disseminate information to members regarding biological control opportunities, policies, procedures, and regulations;

2) to identify potential targets for biological control research, specifically (but not exclusively) in classical biological control, and conduct cooperative regional projects on importation of exotic natural enemies;

3) to develop cooperative research proposals;

4) to conduct basic and applied biological control research;

5) to integrate biological control research into regional pest management programs;

6) to convey the results of biological control research to the general public, and serve as an information resource for agricultural, environmental, and policy-making communities.

The committee currently has representation from 11 states, 2 USDA-ARS (USDA-Agriculture Research Service) laboratories, 1 USDA-APHIS (USDA Animal and Plant Health Inspection Service) laboratory, the National Biological Control Institute, and the International Organization for Biological Control.

The Ladybird Committee was initiated by, and currently operates under the auspices of, NCR-125. The goal of the Ladybird Committee is to increase the implementation and visibility of biological control in the Midwest. Meetings are designed specifically to develop and coordinate active biological control projects in the areas of research, teaching, and extension. Membership is open to all who are interested in contributing time and energy to advance biological control.

The Ladybird Committee, in conjunction with NCR-125, has been very active in a variety of teaching, research, and extension projects. Committee members have cooperated in several extension projects and have developed proposals for several regional extension publications. Several cooperative research and educational projects also have been developed.

Extension Activities

Many segments of society, both

Continued on page 3.

agricultural and nonagricultural, recognize the need for replacing pesticide use with practical, effective, and economical alternatives. Few specific programs or educational materials on biological control are available to growers, consultants, county agents, or other clientele. NCR-125 and the Ladybird Committee, in cooperation with the University of Wisconsin, have initiated the Extension Biological Control Program for the development of crop-specific, integrated pest management manuals that focus on biological controls. These publications are being produced for distribution in the North Central Region. Educational slides also are being produced on each of the topics.

Two regional extension biological control workshops have been conducted, one at the University of Wisconsin and one at Kansas State University. A third workshop is slated for 1995 at Purdue University. These workshops were developed for extension personnel, crop consultants, educators, farmers, and the greater agricultural community. They are designed to introduce natural enemies and their role in the biological control of pest arthropods, and to provide workshop attendants practical approaches for applying biological control.

Education

The successful application of biological control and its growth as a discipline are critically dependent on the education of students. Students of biological control need to learn ecology, systematics, quantitative analysis, and the basic biology of biological control agents. Instructors need current information on theory and techniques, as well as a grasp of the history and practical applications of biological control in the field. NCR-125 and the Ladybird Committee have addressed the need for more graduate-level courses in biological control at midwestern universities and have established the Midwest Institute of Biological Control. Four summer short courses have been conducted and are described in the sidebar accompanying this article.

Research

Over 75 full- and part-time state and federal scientists are engaged in biological control research in 13 North Central states. Research approaches consist of field and laboratory investigations from the molecular to the ecosystem level. Projects focus on a range of basic and applied topics that explore the interactions of predators, pathogens, and parasitoids, and their impact on pest organisms. Target pests include arthropods affecting field and forage crops, livestock, and humans. Some research also is being conducted on the biological control of weeds.

Biological control researchers in the North Central Region produce nearly 100 peer-reviewed journal articles, books, and other research publications per year, and have been highly competitive in procuring extramural funding to support research. In addition, members of NCR-125 have developed a regional planning grant to develop a biological control consortium in the North Central Region. The primary goals of this consortium are to promote, facilitate, and coordinate biological control activities within this region.

NCR-125 has established formal collaborative research and educational opportunities with the Pan-American School of Agriculture in Honduras. Honduran students have completed internships and graduate degree programs at Kansas State University, Purdue University, Iowa State University, and the University of Illinois.

Photo by Lee Solter, INHS Center for Economic Entomology

University of Illinois graduate student Lisa Carloye studies insect pathogens that may be candidates for use in biological control programs.

In the future, NCR-125 and the Ladybird Committee will continue to be active in developing, implementing, and teaching biological control. The committees have every intention of making the Midwest a world leader in biological control and to ensure that the use of natural enemies is the primary management tactic used in integrated pest management.

The Illinois representative to NCR-125 is Robert Wiedenmann of the Illinois Natural History Survey. Rob can be reached at the following address: Illinois Natural History Survey, 172 Natural Resources Building, 607 E. Peabody Dr., Champaign, IL 61820, telephone (217) 333-7405.

A brochure with the names of all state representatives to NCR-125 is available to interested persons from Joseph Maddox (217) 244-5115 or Lee Solter (217) 244-5047.

Lee Solter, Robert Wiedenmann, and Joseph Maddox, Center for Economic Entomology

Horsehair Worms in Illinois

The phylum Nematomorpha (from the Greek *nema*, "thread," and *morphe*, "shape"), consists of a group of invertebrates, commonly called horsehair or gordian worms, that has no close relationships with any other living organisms. The name horsehair is derived from the worm's hair or threadlike appearance in its adult stage. The first known fossil record of this group dates from the Eocene epoch (40-70 million years ago), but experts suggest it may have its roots in the lower Paleozoic Era (over 500 million years old).

As larvae, horsehair worms are parasites of insects and other aquatic and terrestrial invertebrates, most notably grasshoppers, crickets, locusts, katydids, and beetles. Other hosts include caddisflies, dragonflies, spiders, millipedes, centipedes, crustaceans, and leeches. Host specificity has not yet been well documented. Other hosts include representatives of vertebrate groups.

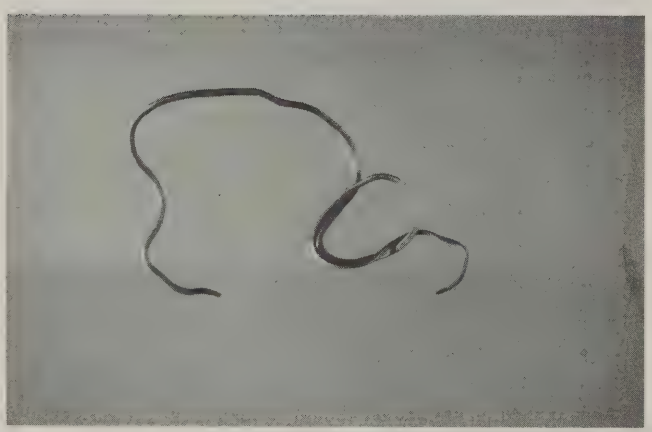

Photo by Kevin Cummings, INHS Center for Biodiversity

Horsehair worm tying itself into a proverbial knot.

Most horsehair worms are observed in their adult, free-living stage among the vegetation near edges of ponds and streams, although a few semiterrestrial species occur in damp soil. A small group of marine species, parasitic on crustaceans, have been collected from coastal environments.

Nematomorphs measure up to 1 meter in length and from less than 1 to 3 millimeters in diameter; diameter is uniform from one end to the other. Color usually ranges between light tan to dark brown, although yellowish and black individuals have been observed. Size and coloration vary considerably, even within the same species. Males are smaller than females, and the two sexes may be found in equal and unequal numbers in the same population. Locomotion of adult horsehair worms is at most a very slow whipping action; males seem to be much more active than females.

Horsehair worms reproduce sexually in spring, early summer, or autumn. Eggs, often numbering in the millions, are laid in long gelatinous strings. For aquatic forms, the incubation period may range between 15 and 80 days, depending upon water temperature.

The mode of development of nematomorphs after hatching has been the subject of much debate. Some experts suggest that the larvae encyst on vegetation or other substrates along the water's edge soon after hatching. Eventually, some of these cysts are ingested by hosts feeding on these substrates. The cyst rapidly degenerates in the digestive tract of the new host. The larva then burrows its way through the intestinal wall into the host's body cavity, continuing its development. When ingested by inappropriate hosts, the cyst may degenerate and then reencyst in the tissues of the host. If this inappropriate host is then ingested by one of its predators (an appropriate host for the nematomorph), the cyst may again disintegrate and continue its life cycle in this new host. Other researchers have suggested that after the nematomorph larva emerges from the egg, it will penetrate the body wall of just about any animal it happens to encounter, although again, normal development will occur only in hosts. This mode of development may occur in the semiterrestrial species of horsehair worms.

After entering the body cavity of an appropriate host, the larva grows to a juvenile stage, then emerges from the host to mature. During the larval stage of development, the horsehair worm digests and absorbs surrounding tissue. This period of metamorphosis occurs over a period of several weeks to several months; eventually the larval form develops into a tightly coiled mass in the host. One to several horsehair worms may occur in a single host. The parasite uses the important nutrients of the host, probably impairing its reproductive system. It has been suggested that hosts seek water when the horsehair worm is ready to emerge, perhaps even being

Continued on page 10

Small Impoundment Fisheries Research at Ridge Lake Station

Almost half of the surface waters in Illinois are impoundments, and of these, 38 percent are 40 acres or smaller in size, representing almost 100,000 acres of water. Because these impoundments receive high angler use (up to 1,000 hours per acre per year), it is important to study ways in which fish populations and angling opportunities in these systems can be maintained. Ridge Lake Station, a Survey fisheries research laboratory located at 14-acre Ridge Lake south of Champaign in Coles County, was constructed in 1941 for the purpose of investigating fisheries management alternatives for small impoundments.

Investigations at Ridge Lake have covered a variety of topics important to the management of small impoundments. From the beginning of operations through the 1960s, studies at Ridge Lake included determination of the effect of water-level management, harvesting strategies, and artificial feeding regimes on bass and bluegill populations. Investigations during the 1970s focused on factors influencing the catchability of largemouth bass. In the 1980s, the influence of predator fish (other than largemouth bass) on bluegill populations was investigated by introducing tiger muskellunge and later walleye. All of these projects included a public angling program, with Survey biologists collecting information on catch, harvest, diet, and growth of fish from all anglers using the lake.

Current research at Ridge Lake Station is aimed at determining how fish managers might manipulate forage fish populations (primarily gizzard shad) to improve populations of predator fish such as largemouth bass and walleye. Forage of the appropriate size and type can be important to the survival and growth of predator fish. Fish managers can manipulate forage populations by introducing new species or by taking steps to alter the size structure of existing forage populations.

Introductions have been used with mixed success, and the reasons for failures are not fully understood. Adult gizzard shad were accidentally introduced into Ridge Lake from an upstream impoundment in the fall of 1989, and Ridge Lake researchers took that opportunity to assess the influence of gizzard shad on the growth, survival, catch, and harvest of largemouth bass, bluegill, black crappie, and walleye in the lake. Information gathered in this study also will lead to a better understanding of basic ecological concepts related to "food web" interactions.

Gizzard shad had little influence on walleye survival; density of forage fish other than gizzard shad (e.g., young bluegill) appeared to be a more important factor. In contrast, gizzard shad had a substantial impact on largemouth bass and bluegill survival, possibly through competition for planktonic food among young fish or interference with spawning activities. Growth of walleye increased dramatically following the introduction of gizzard shad, whereas growth of bass, bluegill, and crappie did not appear to be affected.

With the introduction of gizzard shad to Ridge Lake, researchers expected to see increases in the size and number of fish caught and harvested due to the presence of an additional food source. Contrary to these expectations, both catch and harvest of largemouth bass declined markedly to about one-third of previous levels. Catch of walleye and bluegill differed little between pre- and post-shad introduction time periods, whereas catch of black crappie more than doubled. With the exception of black crappie, size of fish caught also did not change following the introduction of gizzard shad to Ridge Lake.

Photo by David Clapp, INHS Center for Aquatic Ecology

Ridge Lake Biological Station

Current research at Ridge Lake has shown that the effects of introducing gizzard shad may be positive or negative, depending on the species of fish and population characteristic of interest. Introduction of forage fish to improve game fish populations should be done only with caution and after careful consideration of management objectives. Future fisheries investigations at Ridge Lake will continue to include work that will help fishery managers develop angling opportunities on the important small impoundment resources of the state of Illinois.

Dave Clapp and David H. Wahl, Center for Aquatic Ecology

Species Spotlight

Green Tree Frog

Susan Post

An encounter with a green tree frog will certainly pique the curiosity of almost anyone. This amazingly colored frog, usually found in cypress swamps, floodplain sloughs, and cattail marshes of the southern United States, also resides along the floodplains of the Mississippi and Ohio rivers in the extreme southern tip of Illinois — in Alexander, Union, and Jackson counties. Considered one of the most beautiful tree frogs in North America, the coat of *Hyla cinerea* is very smooth and ranges in color from a bright leaf green to an olive green with a white to yellow stripe extending along its sides from the jaw to the thigh. The green tree frog is 1.75 to 2.5 inches long and has a very slender form. Its legs are 1.5 times the length of its head and body, which enables it to leap distances of 8 to 10 feet. Like all members of the tree frog family, the green tree frog has rounded adhesive discs on its unwebbed toes (these enable the frogs to climb) and horizontal pupils in its eyes.

Photo by Michael Jeffords, INHS Center for Economic Entomology

Green Tree Frog (Hyla cinerea)

By early May adult green tree frogs make their presence known. During the day the frogs crouch motionless in vegetation in and around water, relying on their coloration to protect them from predators. Each evening the nocturnal choruses of the males resound throughout the swamp. Their chorus has been compared to the sound of cowbells, and from early May to early August, when the temperature is above 68 ° F, the frogs chorus in hopes of attracting a female.

After mating, females propel the eggs backward, where they adhere to floating vegetation. Within 2 to 3 days the eggs hatch and the young larvae are nothing more then a head with a strong muscular tail. Two common names have been applied to larval frogs: tadpole, which means toad's head, and pollywog, which means wiggling head. The green tree frog tadpole stage lasts from 4 to 6 weeks. During this time numerous internal and external changes take place as the tadpole metamorphoses into an adult.

By mid-August the breeding pond is silent, the adults have gone, and the developing tadpoles and subadults continue to eat and grow. By autumn the young frogs have moved into grass and woodlands surrounding the breeding area to overwinter. It takes a year for green tree frogs to reach sexual maturity, so by late summer of the following year the young frogs will be able to join the adults in the annual chorus.

Teacher's Guide to "The Naturalist's Apprentice" (facing page)

Frog Metamorphosis: A Change for the Better

Objective: to introduce students to the concept of metamorphosis as practiced by frogs.

Materials: multiple copies of **Frog Metamorphosis,** scissors, colored pencils or crayons, transparent tape, thread, and straws.

Vocabulary: metamorphosis, tadpole, membrane

Comments: One of the most familiar phenomena in nature is the metamorphosis of a tadpole to an adult frog. This installment of *The Naturalist's Apprentice* is for younger students and will allow them to explore the ephemeral world of the frog. Each spring marks an annual ritual — male frogs sitting and singing around ponds and lakes, hoping to attract a mate. The apparent sudden appearance of long strands of jelly-like eggs in most bodies of quiet water attests to their success. Tadpoles soon break out of the jelly-like membrane of the eggs and become free-living, feeding mostly on algae and other vegetable matter in the water. A gradual yet remarkable change now begins. Hindlegs appear first, soon followed by miniature front legs. As the tadpole and its legs grow larger, its tail decreases in size. Soon, on a warm spring or early summer day, the change is nearly complete and an adult frog appears on the shore. It will spend the summer growing strong and fat, preparing for its participation in the next year's "rite of spring."

Procedure:

1. Introduce the activity with observations from *Species Spotlight* and the comments section above.
2. Distribute copies of **Frog Metamorphosis**. Students color the life stages of the frog, cut out each stage, and fold to make a complete animal. Suggestions for coloring are provided on the sheet. The fold will give the various life stages a three-dimensional look.
3. Students use the completed cutouts to make a mobile to display the frog's life cycle. Below is a suggested design for your frog mobile.

Prairie Chickens

continued from page 1

A third release in early April 1994 on booming grounds in Jasper County involved 96 birds from Kansas composed of 50 hens (23 radioed) and 46 cocks (6 radioed). Four of the 6 radioed Kansas cocks became active boomers among the mix of 5 to 6 Illinois cocks, 2 Minnesota cocks, and 10 unradioed Kansas cocks. Thirteen (56%) of the 23 radioed hens stayed on or near the sanctuaries in Jasper County, 10 of the 13 were verified as nesters, and 7 of the 10 nests hatched young. Of the 7 radioed brood hens, 3 evidently fledged young. Extrapolation from the performance of the radioed birds suggested that 3 to 4 unradioed Kansas hens reared young and that 27 unradioed Kansas cocks may have participated in booming. The number of boomers (Illinois and Minnesota combined) nearly tripled after the release of Kansas cocks, but the extrapolated estimate of 27 unradioed cocks may be an overestimate.

Fertility and hatch rate of total eggs was high (99 percent and 94 percent, respectively) for a sample of 18 prairie chicken nests in 1993-94; 15 of these nests involved radioed hens and most were probably hybrid clutches. None were parasitized by pheasants, in contrast to parasitism rates that reached 43% in the mid-1980s. Indeed, no pheasant eggs occurred in 47 prairie chicken nests observed during 1988-94, following intensive pheasant control implemented by IDOC in 1986 in Jasper County.

We were pleased with the performance of the Minnesota and Kansas birds translocated to Illinois. Expectations based on similar studies (except that no prairie chickens were already in place) in other states were exceeded and therefore are encouraging. Genetic and demographic enhancement of remnant Illinois stock appears to have been successful. On the downside, the last vestiges of possible racial distinction in Illinois prairie chickens will likely cease to exist with the 1994 breeding season. The unexpected appearance of a Minnesota cock in Marion County some 40 miles from the Jasper County release site suggests that the genetic transformation may have included both of Illinois' remnant "populations." Nevertheless, we are guardedly optimistic that Illinois can continue to have wild populations of prairie chickens. Ongoing efforts to develop a minimum of 1,500 acres of sanctuary grasslands in both Jasper and Marion counties (3,000+ acres, total) continues to be a basic critical need for the two restored grassland ecosystems.

Ron Westemeier and Roger Jansen, Center for Wildlife Ecology

Spawning

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to intermediate in quality.

It was interesting to see the different results for muskellunge and northern pike eggs, and we believe they correspond to the differences in breeding biology between the two species. Even though both fish spawn at the same time and in the same general manner, muskellunge prefer to lay their nonadhesive eggs in highly ventilated, well-oxygenated areas of water (i.e., lotic or riverlike environments), whereas northern pike prefer to lay their adhesive eggs in marshy or swampy areas of water (i.e., lentic or lakelike environments). Of all the substrates, gravel best provides the well-oxygenated, clean environment needed for muskellunge eggs. Of the substrates that are good to intermediate for northern pike, most are organic in nature, which matches the swampy environment they desire.

We hope that the information obtained in this study will help fisheries managers as they attempt to turn back the hands of time and successfully restore muskellunge and northern pike spawning areas.

Doug Wojcieszak and David H. Wahl, Center for Aquatic Ecology. Vic Santucci, Max McGraw Wildlife Foundation

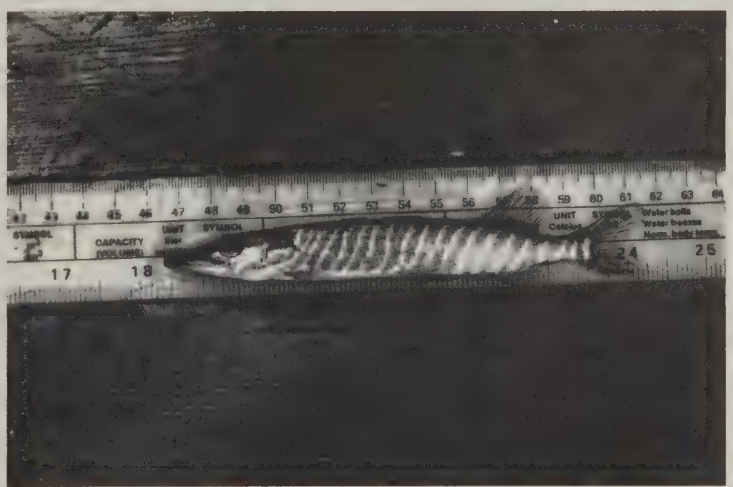


Photo by David Wahl, JNHS Center for Aquatic Ecology

Northern Pike

Restoration of Muskellunge and Northern Pike Spawning Areas

Muskellunge and northern pike are closely related, popular midwestern sport fish that have recently become "reproductively challenged." Historically, muskellunge and northern pike moved to shallow waters during the early spring months to spawn. Males and females would pair up and release millions of eggs that drifted to the bottom where, without parental care, they developed in the substrate (bottom material) and hatched in 1 to 2 weeks time.

Unfortunately, this annual right of spring was interrupted by modern-day pollution and development that destroyed many spawning areas. To maintain population levels, fisheries managers have had to raise muskellunge and northern pike in hatcheries and stock them in the wild. However, there is now an interest in turning back the hands of time — restoring the spawning areas — and having muskellunge and northern pike successfully reproduce.

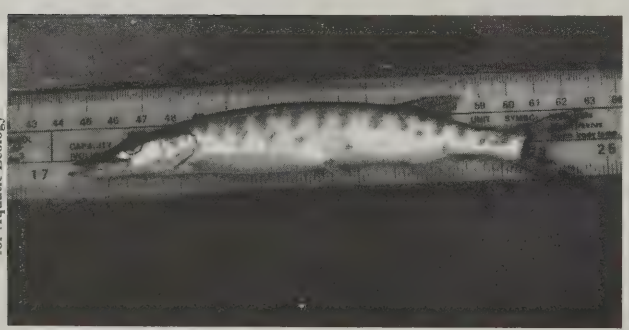


Photo by David Wahl, INHS Center for Aquatic Ecology

Muskellunge

Restoration projects have been attempted for both muskellunge and northern pike. These projects have entailed activities such as reclaiming swampy and marshy areas to placing certain substrates in areas where fish are thought to spawn. Unfortunately, restoration efforts have been hit-or-miss propositions; sometimes they've worked, other times they have failed to aid northern pike and muskellunge reproduction.

In reviewing past restoration attempts, it was evident that we do not know which substrate (or substrates) is best for muskellunge and northern pike spawning areas. Substrates are important because they establish an environment for fish eggs. Some substrates are known to smother eggs, but others provide support and aeration. Some substrates provide oxygen to the eggs, while others take it away. Some substrates are even thought to give off chemicals that inhibit bacterial and fungal growth, thus providing protection to the developing eggs.

The object of our study was to find the best substrate(s) for northern pike and muskellunge eggs. We tested the survival of muskellunge and northern pike eggs on the following substrates (grouped into four categories):

1. Live submerged plants:
   - *Potamogeton crispus* (curly leaf pond weed)
   - *Myriophyllum* sp. (Milfoil)
   - *Chara* sp.
2. Dead plants:
   - *Typha* spp. (cattail)
   - Sedge grass
   - Dead leaves (oak, maple)
   - Wood
3. Artificial plastic plants
4. Nonplant substrates:
   - Clean gravel
   - Sand
   - Compacted mud

We constructed this list of substrates from past papers on muskellunge and northern pike breeding biology. Each paper suggested a different substrate or group of substrates as being the best for muskellunge and northern pike spawning areas. The 11 substrates listed above were mentioned most often in the articles we read. (The plastic plants, like those you find in pet stores, were not mentioned in the articles, but we thought it was important to include them in the study because restoration project managers might be interested in using them.)

The substrates were placed into 1-gallon glass jars in our laboratory. We had 55 1-gallon glass jars, which meant there were five jars per substrate, or five repetitions per substrate. The water temperature in the jars was held constant at 13 ° C (the spawning temperature for muskellunge and northern pike) and the light was on a 12:12 cycle — 12 hours of light and 12 hours of darkness.

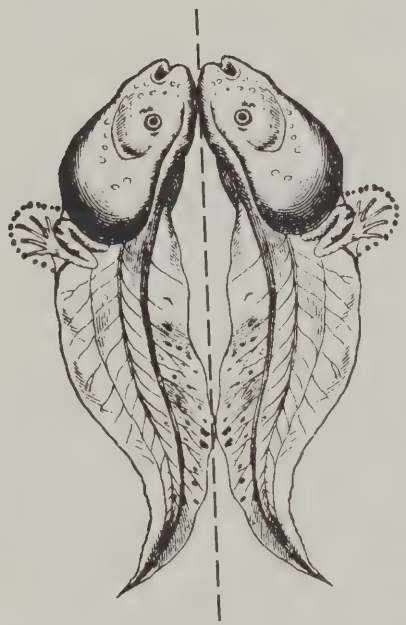
We obtained two batches of muskellunge eggs and two batches of northern pike eggs. We placed 50 eggs into each jar, and we tested one batch of eggs at a time, alternating between muskellunge eggs and northern pike eggs.

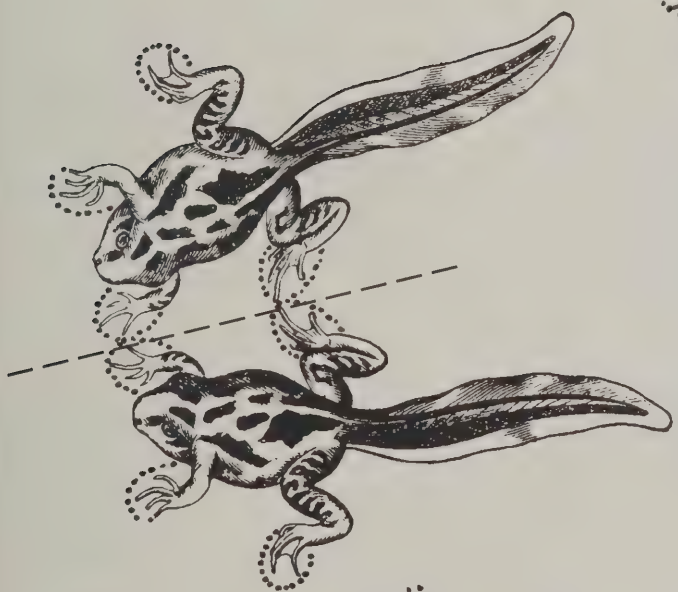
On a daily basis over a two-month period, we tracked the hatching and survival of the muskellunge and northern pike eggs. For muskellunge we found that gravel is the best substrate, while sand, mud, and *Myriophyllum* are poor. The remaining substrates of *Potamogeton*, *Chara*, cattail, dead leaves, wood, artificial plants, and sedge grass were intermediate or "so-so" for muskellunge survival. For northern pike we found *Myriophyllum*, wood, and mud are poor, whereas the remaining substrates were good

Continued on page 9

og Metamorphosis

lor and cut out the different stages of a frog's life cycle. e egg has a brown center, the tadpoles are greenish wn with reddish-black markings. The adult frog is green h a yellow stripe down its side. Its eyes are red. After ting out the mobile parts, fold them along the dotted es.





The Naturalist's Apprentice

Frog Meta-morphosis

Michael Jeffords

"The Naturalist's Apprentice" presents educational activities for middle school students. Teachers are invited to photocopy this page for classroom use.

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Worms

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driven to water by some physiological cue. Once the host enters the water, the horsehair worm breaks through the body wall of the host. Newly released horsehair worms soon die if they do not have access to water.

Several stories are associated with Nematomorpha. A common name of nematomorphs is gordian worm, which originated from its similarity in appearance to a knot, specifically one created by Gordius, king of Phrygia, around 330 B.C. As the mythical story goes, Gordius used this knot to bind a chariot to a pole. He declared that whoever could undo the knot would be ruler of all Asia. The name horsehair worm might also originate from what ancient observers perceived as the spontaneous transformation of hairs from horses that, having fallen into watering troughs, developed into living worms.

Over 230 species of nematomorphs have been described worldwide. Unfortunately, taxonomic and ecological studies of this group in North America are limited compared to those of other invertebrate groups. At least 4 and possibly as many as 16 genera occur in North America. Identification of species has been difficult in many cases because characteristic features have been limited to microscopic surface patterns and the sculpturing of the cuticle. Recent light and scanning electron microscopical studies by several researchers have contributed important systematic information to the study and classification of this group. To date, only two species of horsehair worms are known to occur in Illinois, *Gordius robustus* and *Paragordius varius;* a third species, *Chordodes morgani*, known to occur in states surrounding Illinois (Iowa, Wisconsin, Michigan, Tennessee, and Ohio), most likely occurs here, also. Additional collecting and study of specimens currently being conducted by the authors of this article undoubtedly will add to the number of species that occur in Illinois.

A common name of nematomorphs is gordian worm, which originated from its similarity in appearance to a knot, specifically one created by Gordius, king of Phrygia, around 330 B.C.

Mark J. Wetzel, Center for Biodiversity, and Dreux J. Watermolen, Wisconsin Department of Natural Resources, Madison

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INSIDE

Helicopter Captures Russian Wheat Aphids

Russian wheat aphids (RWA), *Diuraphis noxia* (Mordvilko), were introduced into the United States less than 10 years ago. Since that time they have spread rapidly throughout the drier regions of the western United States and Canada, where they are major pests of many small grains, particularly wheat and barley. RWA suck the juices from these plants, stunting their growth and substantially reducing grain yields. These aphids reproduce quickly in leaf sheaths of small grain plants, where they are protected from predators, parasitoids, and pesticides.

Knowledge of the dispersal dynamics of RWA is critical to improving our ability to monitor and predict infestations of these aphids. RWA dispersal may be either local or long distance, depending in part upon atmospheric conditions. Before we can forecast aerial movements of this important pest, we need to understand the meteorological factors that govern the vertical distribution of RWA in the atmosphere. Because wind speed and direction often change dramatically with altitude above the earth's surface, the flight paths and destinations of weak-flying insects such as RWA can differ substantially, depending upon their altitude of flight.

Local movements of RWA generally occur on clear, warm days when the sun heats the earth's surface, producing convection (rising air parcels) in the lower atmosphere. These thermals can carry weak-flying insects upward, often as high as 1 mile. Subsiding air parcels return many insects to the ground, usually in the local environment or a few miles downwind. At night the atmosphere generally becomes stable and layered. On clear evenings, warm air layers with strong southerly winds (low-level jets) often develop after dark from 500 to 1,000 ft. above the ground. Weak-flying insects caught up in the lower atmosphere in late afternoon often find themselves in these low-level jets, where they can remain until morning. Winds in these jets can exceed 20 m.p.h.; consequently, insects that ride them all night can find themselves hundreds of miles downwind by morning.

Photo by Gail Kampmeier, INHS Center for Economic Entomology

Helicopter used in RWA dispersal dynamics study.

The objective of our multidisciplinary, multi-institutional research team was to investigate the dispersal dynamics of the RWA on the high plains of eastern Colorado. The research project was funded by the Western Regional Integrated Pest Management (IPM) Grant Program and the National Science Foundation. The University of Illinois contingent of the team consisted of Gail

Continued on page 2

Russian Wheat Aphids

continued from front page

Kampmeier and Michael Irwin (Illinois Natural History Survey [INHS] entomologists), Scott Isard (biometeorologist, UI Department of Geography), Mark Belding (electronics technician, Illinois State Water Survey [ISWS]), and Rick Jachowske (helicopter pilot, UI Institute of Aviation). This group was charged with collecting RWA and concurrently taking meteorological measure-

INHS Center for Economic Entomology

Russian wheat aphids in open sheath of winter wheat.

ments (pressure, temperature, humidity, and wind speed and direction) throughout the lower atmosphere. To achieve this, Doyle Dazey (INHS) hauled the UI's helicopter and insect collection pods to Greeley, Colorado, where entomological and CHILL radar teams from Colorado State University joined us for two intensive field programs, each lasting two weeks, during May-June 1993 and 1994. The CHILL radar was developed by researchers at the University of Chicago and ISWS.

Much of the instrumentation used in this research was developed and tested in the mid-1980s as part of the Pests and Weather Project funded by the Illinois Department of Energy and Natural Resources. During that three-year project, scientists from INHS, ISWS, and the University of Illinois studied how weather influences the immigration to Illinois of important agricultural pests, particularly the corn leaf aphid.

Our large torpedo-shaped insect collection pods are unique. The helicopter carries one collector on each of its two skids. During flight, the volume of air flowing through each pod is continually regulated by a computer-controlled set of fins at the rear of the collectors. After passing through the forward orifice of the pods, the air enters an expansion chamber where its velocity is reduced. The insects contained within it are slowed down and funneled, relatively unscathed, by a cone-shaped screen mesh into small collection chambers. Each pod can collect 12 samples during a single helicopter flight.

This technology allows us to sample a predetermined volume of air at multiple altitudes in a single helicopter flight. When the pilot reaches the first altitude to be sampled, he pushes a button on the computer causing the first door of the collection chamber to close. The computer monitors the air flowing into each pod until the prespecified volume has been sampled (usually 1,000 m^3 in about 5 minutes), at which time a second door automatically drops, sealing the sample. The pilot then proceeds to the next flight altitude where he repeats the procedure. We generally flew two or three flights per day over the two-week periods, each flight lasting nearly two hours. When the helicopter returns to the airport, insects are removed from the collection chambers, counted, and identified to order. Live RWA are frozen so that they can be analyzed for flight fuels to determine how long they had been flying.

Free-floating radiosonde probes (automated weather data collection devices) attached to helium-filled balloons were used to determine atmospheric conditions at the same times and in close proximity to the actual atmospheric volume from which the aerial insect collections were made. The sonde transmits pressure, air temperature, and humidity readings every 10 seconds as it rises through the atmosphere to our Atmospheric Data Acquisition System. Visual tracking of the bright red balloon using a theodolite allows us to determine wind speed and direction. These important meteorological factors are displayed graphically in near-real time at the base station.

The CHILL radar was operated throughout each collection flight in Greeley, sweeping the atmosphere for return echoes from insects (traditionally referred to as angel echoes). In addition to insect layer concentrations (which could be "seen" up to 50 miles away), the CHILL could detect the position of the helicopter. Information on both the meteorological conditions and the location of insect concentrations in the lower atmosphere was radioed to the pilot and used to direct the helicopter to specific atmospheric layers for sampling.

We caught over 400 arthropods in 1993; unfortunately, none of them were RWA. However, nearly six

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Factors Affecting Growth of Reservoir Fish

Growth is an important component of the ecology of fishes. It has been shown that larger fish are more capable of producing offspring, less susceptible to predation, and are often better competitors than smaller fish. Also, for most anglers, large fish are what fishing is all about.

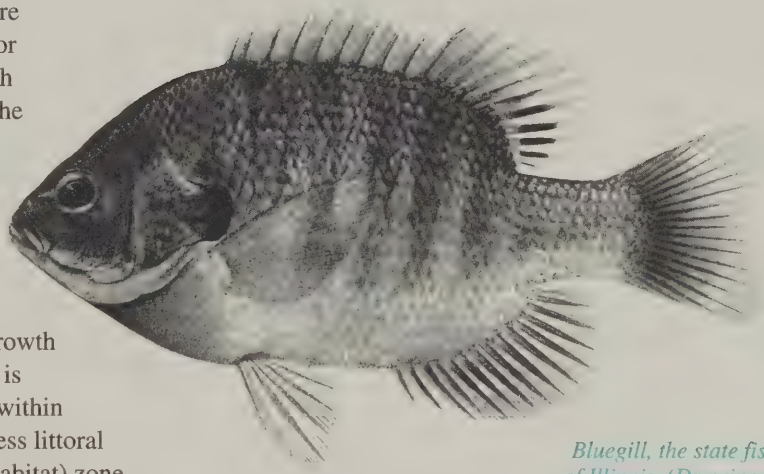
Why do fish in one lake grow larger than those in another? Numerous studies that have attempted to answer this question indicate that growth can be affected by factors such as temperature, water clarity, food availability, and preferred habitat availability. However, most of this work has either focused on a single species or has been restricted to a solitary lake.

There is a need for the development of growth models comparing multiple lakes and multiple species. The purpose of our project is to develop general predictive growth models for three functional feeding groups of fishes: a piscivore (largemouth bass), an insectivore and planktivore (bluegill), and a benthic omnivore (channel catfish). Fisheries managers will be able to use readily available information from these models to make decisions about fishery operations.

A number of lakes throughout Illinois were sampled monthly to assess several variables that might affect the growth of fishes, such as levels of food resources, limnological factors (physical and chemical characteristics), and fish abundances. These values were then examined for relationships with growth rates of the three fish species.

We examined several factors that appear to affect growth rates. Growth of small bluegill is relatively faster within lakes that have less littoral (shallow water habitat) zone. We believe this is due to predation pressures forcing small bluegill into littoral cover. Higher densities of bluegill in the littoral zone and a lower net energy diet than that in the open water results in slower growth. Lakes with less littoral zone have bluegill feeding on the higher net energy diet of open water zooplankton and higher rates of predation mortality due to a lack of cover. Lower numbers of bluegill and less competition result in faster growth. Also, results indicate populations of bluegill in southern lakes grow more in a year than those in northern lakes.

Largemouth bass growth, at least at smaller sizes, appears to be positively related to the density of forage fish in the lakes. Common littoral zone fishes, such as juvenile bluegill, and golden shiner and other minnows, are an important component in the diet of largemouth bass. Higher densities of these prey fish allow for faster growth of largemouth bass.



Bluegill, the state fish of Illinois. (Drawing by INHS artist Lydia Hart originally appeared in The Fishes of Illinois *in 1908.)*

Analysis has also revealed that populations of relatively fast-growing channel catfish are found in lakes with larger littoral zones. We believe that with higher proportions of shallow-water habitats the catfish have a larger area in which to feed.

There is still much to learn about what drives growth rates in natural populations of fish. Our preliminary data indicate a number of important factors. Ongoing data collection and analysis will reveal if there are any additional environmental qualities that influence growth rates in fish. Identification of these factors will then enable us to develop growth models for use by fisheries managers.

Sean P. Callahan, David H. Wahl, and Clay L. Pierce, Center for Aquatic Ecology

Kentucky Warbler Population Dynamics in a Forest Mosaic

During the past 15 years there has been an ever-increasing concern for the fate of many species of nongame forest birds that winter in the tropics (neotropical migrants). Several lines of evidence suggest that they are declining over much of their range. Forest fragmentation and the creation of forest edges on breeding sites in the temperate zone have been implicated as possible causes of this decline. Areas in Illinois where

Male and female Kentucky warblers. (From original painting by INHS researcher Solon Morse.)

continuous forest once stood are now dominated by a mosaic of forested and nonforested habitats. The combination of elevated levels of both nest predation and brown-headed cowbird parasitism in such a mosaic significantly diminishes reproductive success, and thus recruitment, of many forest-dwelling migrants.

Indeed, while small forest "islands" harbor large numbers of edge-associated nest predators, such as raccoons, skunks, and blue jays, the agricultural openings surrounding them maintain unusually high populations of nest-parasitic cowbirds. Cowbirds lay their eggs in the nests of other species, and are entirely dependent on the hosts for raising the cowbird young. Large populations of cowbirds can have serious effects on host reproductive success primarily because female cowbirds remove host eggs prior to laying their own and they can parasitize a single nest multiple times. Parasitized nests frequently fledge few or no host young.

With a few exceptions, the dynamics of neotropical migrant populations are poorly understood, especially for forest-interior species. Most studies rely on crude measures of nesting success and return rates of adult birds. We lack detailed demographic and life-history data about the diverse factors influencing reproductive output and age- and sex-specific return rates of adults in relation to previous nesting success. Until these critical gaps are filled, we will not know the levels of nest predation and parasitism that populations can tolerate. Such detailed, species-specific data are crucial before effective conservation plans can be formulated. · I am currently investigating the impact that a mosaic consisting of intact forest, disturbed forest (clearcuts and tree plantations), and agricultural fields has on the reproductive success and dynamics of a population of Kentucky warblers in the Shawnee National Forest in southern Illinois.

At many sites in Illinois, Kentucky warblers experience moderate but variable levels of both nest predation and cowbird parasitism and seem to be somewhat tolerant to fragmentation. Populations may be quite high in selectively logged tracts of forest, tree plantations, mid-successional clearcuts, and other disturbed forest where understory cover is abundant. Kentucky warblers also occupy territories adjacent to forest edges and choose nest sites usually within a meter or two of an edge created by a trail or stream. However, my results indicate that the production of Kentucky warbler young is very low in disturbed habitats and along agricultural edges — even though Kentucky warblers may be drawn to them — due to both elevated levels of nest predation and parasitism.

I found that predation of nests is the primary cause of nest failure, and that predation increases with increasing levels of forest disturbance. In undisturbed forest, nearly 45% of all nests successfully fledge young. Half of the females successfully fledging first attempts build second nests following fledgling independence. Some double-brooded females fledge as many as nine young in a single season. By contrast, in clearcuts, along forest/field edges, and in the tree plantation (which superficially resembles undisturbed forest) only 16%, 25%, and 30% (respectively) of all nests successfully fledge young. Most females will attempt to renest two or three times (and very rarely four) following failure, but because clutch size decreases and nest predation

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Western Corn Rootworm Problems

Western and northern corn rootworms are the most serious insect pests of nonrotated corn in the Midwest. In June 1987, severe corn rootworm larval injury to corn grown for seed production (inbred corn) was reported within a 1-square mile area near Piper City in Ford County, Illinois. The injury to corn roots occurred in six fields that had been planted to soybeans grown for seed production the previous year. All fields were free of volunteer corn or heavy weed infestations in 1986. Since that time, my laboratory has been trying to find the cause for this damage. The severe corn rootworm problem reoccurred in the same area in 1988 and in the years since.

We quickly determined that the damage was caused by the western corn rootworm, not the northern corn rootworm. This was unexpected because prolonged diapause or dormancy is well known in the northern corn rootworm and only recently has it been reported in the western corn rootworm, but at very low levels (less than 0.2% of any eggs observed). Prolonged diapause allows eggs to pass through two or more winters before hatching rather than the normal one winter pattern. Egg hatch studies with eggs from the Piper City population of western corn rootworms, however, did not show *any* evidence of prolonged diapause.

Although egg laying by Piper City western corn rootworms was indeed taking place in soybean fields, a large field study with different plantings of soybeans in Urbana, less than 60 miles away, confirmed earlier published studies that neither western nor northern corn rootworms lay enough eggs in weed-free soybean fields to cause economic damage to a subsequent crop of corn. Because western corn rootworm adults are quite mobile and considerable genetic mixing is thought to occur, we expected that Urbana and Piper City populations would show similar egg-laying behavior.

We also investigated the possibility that western corn rootworms may have laid eggs in the Piper City soybean fields because pyrethroid insecticides used on neighboring seed corn may have repelled rootworm females into the nearby soybean fields. Pyrethroid insecticides are routinely used for corn earworm control in seed corn and are typically applied during the first two weeks of August, the period of initial corn rootworm egg-laying. In several laboratory bioassays, we demonstrated that permethrin, a pyrethroid insecticide, could repel western corn rootworms from treated corn and cause them to lay eggs in untreated soybeans. We concluded that the situation at Piper City could very well have been caused by pyrethroid insecticide use.

During the summer of 1993 we received a few reports of rootworm larval injury to first-year seed or commercial (hybrid) corn following soybeans outside the Piper City area (but still in east-central Illinois). One of the fields was a seed cornfield in Flatville where pyrethroid insecticides were routinely used for corn earworm control. The remaining fields were in the Homer area and involved commercial corn with no history of pyrethroid use in the immediate area. Corn rootworm larval injury was severe in the Flatville field and moderate in the Homer fields. The western corn rootworm was overwhelmingly the predominant species in both areas. Western corn rootworm eggs from females collected in the Homer area were subjected to natural overwintering conditions in the laboratory. Eighty-three percent of the eggs hatched and 11% remained unhatched, but appeared to be in good condition, by the end of June 1994. These eggs are being subjected to another overwintering cycle. If they hatch in June 1995, we will know that they have the prolonged diapause trait. As mentioned earlier, the percentage of western corn rootworm eggs found with the trait has been less than 0.2%. If a large portion of the Homer eggs hatch in 1995, this would certainly be cause for concern.

Photo by Eli Levine, INHS Center for Economic Entomology

Western corn rootworm beetle on corn leaf.

During the summer of 1994, a number of new reports of rootworm larval injury to first-year commercial corn following soybeans were received, again all in east-central Illinois. One field near Dewey, several fields near Crescent City, and a couple of fields near Sibley sustained severe rootworm injury. The predominant species was the western corn rootworm in the fields near Dewey and Crescent City. The fields near Sibley also contained sizable populations of northern corn rootworm adults, so prolonged diapause in the northern corn rootworm cannot be ruled out. Pyrethroid use in the vicinity of all these fields was minimal. Eggs were

Continued on page 9

Species Spotlight

Millipedes

Susan Post

Millipedes are one of the few life forms that can give us a flashback glimpse of early life. Century after century, eon following eon, they have survived, coming down to the present day almost unchanged. Occupying dark moist habitats, they are seldom seen except on rainy days, perhaps crossing a wet log. In more pleasant weather, if someone happens to roll over a millipede's log home, the creature will be revealed slowly moving away from the disturbance.

Photo by Michael Jeffords, INHS Center for Economic Entomology

The millipede Narceus, *pictured here, is the largest millipede in the state, sometimes reaching a length of 5 inches.*

Millipedes belong to the class Diploda, which literally translated means "thousand legs," although they never have that many. Millipedes have a long, cylindrical, segmented body that has 25 to 100 segments. Two pairs of legs are found on each body segment except for the three segments following the head. These segments, called the thorax, have only one pair of legs per segment. Despite their many legs, millipedes move very slowly. Their bodies are adapted for pushing through decaying leaf litter and burrowing into the soil, not for sprinting. They glide slowly, successive waves of movement passing along rows of legs.

Due to the their slow movements, millipedes would be an easy target for predators if they didn't have several means of defense. When disturbed, they curl themselves into a tight spiral with the head, numerous legs, and the vulnerable body parts in the center of the protective casing. If this does not deter predators, the millipedes also have a system of chemical warfare. When threatened, a millipede can discharge an obnoxious toxic liquid containing hydrocyanic acid from a row of glands along each side of its body. Despite these defensive adaptations, shrews do not hesitate to eat them, and in some forest habitats millipedes make up the bulk of a shrew's diet.

Millipedes are found throughout Illinois, living among leaf litter, under bark, or in rotting logs. During dry weather they may burrow into the ground. Millipedes are vegetarians, feeding chiefly on decomposing plant tissues.

Female millipedes have very little maternal instinct. Once the female lays her eggs in the ground, enclosing them in an earthy capsule, she leaves. When the young hatch they have six segments and only three pairs of legs and resemble wingless insects. The young grow in length by molting. With each molt the millipede will add three or more segments and additional legs. Millipedes have a life span of two to seven years.

Creatures like the millipede, with its multitudes of legs, may seem unpleasant to some people, but they are not dangerous. The gentle millipede does not bite and it performs a valuable service for humans: it is one of nature's best composters—eating decaying plants and returning the organic matter to the soil.

Teacher's Guide to "The Naturalist's Apprentice" (facing page)

The Legs Have It!

Objective: to understand the relationship between insect leg shape and function

Materials: multiple copies of **The Legs Have It!**

Vocabulary: cursorial, raptorial, natatorial, fossorial, saltatorial, coxa, trochanter, femur, tibia, tarsus, pretarsus

Comments: Most insects have three pairs of legs, one pair on each segment of the thorax. Each leg has six different parts: the coxa, trochanter, femur, tibia, tarsus, and pretarsus. This edition of *The Naturalist's Apprentice* looks at how insect legs are adapted to perform different functions in nature. The most primitive type of insect leg is used for walking or running. Over the 300 million years or so that insects have been around, their generalized walking legs have become adapted for a wide variety of functions, such as grasping, jumping, digging, and swimming.

Procedure:

1. Introduce the subject of insect locomotion by talking about the insect leg.

2. Distribute copies of **The Legs Have It!** and have students match the description in column 1 with the correct insect/leg picture in column 2. *Answers:*

1. digging and walking
2. swimming
3. jumping
4. walking
5. grasping
6. digging and running
7. swimming
8. jumping
9. walking
10. grasping and swimming

3. Have students learn to pronounce and spell the scientific terms for the various types of leg functions.

Kentucky Warblers

continued from page 4

increases throughout the summer, renesting attempts rarely produce many young.

Unlike nest predation, the level of cowbird parasitism is not related to forest disturbance but is determined largely by proximity to agricultural fields bordering the forest tract. In the forest closest to these fields, 56% of the nests are parasitized. Parasitism drops to 20% at 1 km and only approaches 0% at 2 km away from the fields. Cowbird parasitism does not preclude the production of host young entirely. Parasitized nests usually fledge one or two Kentucky warblers as long as a few host eggs remain in the nest to hatch. However, unparasitized nests fledge 2.5 times more host young than do parasitized nests. The major costs of parasitism are in the initial 50% egg removal and in a 20% decrease in hatchability of the remaining host eggs.

The highest fledging success recorded for Kentucky warblers on my site is low compared to that measured elsewhere (70%), and productivity—a function of fledging success and cowbird parasitism—is only slightly more than half that measured for other neotropical migrants in unfragmented forest (2.4 versus 4.5 young produced per female per year). Coupled with high post-fledging and migration mortality, it is unlikely that these birds are producing enough young to replace themselves. Furthermore, the return of adults to breed the following year is much lower at this site than measured elsewhere (43% versus 65% returning) and may be related to low nesting success. Both males and females are half as likely to return following failure during their first breeding season compared to birds that successfully fledge young. Low adult return rates mean that this population is critically dependent on immigrants from other areas for persistence.

My data are consistent with those collected by Scott Robinson of the Survey at other sites in southern Illinois. Collectively, these results suggest that Kentucky warbler reproductive output would benefit from large continuous tracts of undisturbed forest and they imply that caution must be used in assuming the viability of populations based on the presence of adults alone. Although Kentucky warblers will use a variety of disturbed habitats — and are frequently at high densities in them— such habitats may act as population "sinks" in that adults are lured in from the surrounding landscape but subsequently fail to reproduce. For a forest tract to provide some measure of cowbird-free space, the nearest agricultural edge must be more than 2 km from the center of the tract. Continuous forests of this size are rare in southern Illinois, and all but absent to the north. In other parts of the Kentucky warbler's range, however, nest predation and cowbird parasitism are much lower. As long as these distant source populations continue to subsidize our local populations, the Kentucky warbler is likely to persist in Illinois.

Solon Morse, Center for Wildlife Ecology

Photo by Solon Morse, INHS Center for Wildlife Ecology

Kentucky warbler nest parasitized with cowbird eggs.

Rootworms

continued from page 5

obtained from western corn rootworm females collected at Dewey, Crescent City, and Sibley and from northern corn rootworm females collected at Sibley to check for the prolonged diapause trait. Preliminary results will not be available until June 1995 and a final determination will have to wait until June 1996.

Rootworm beetles are found frequently in soybean and alfalfa crops during the growing season. However, that does not necessarily mean that they are depositing their eggs in these locations. Although we did not find significant western corn rootworm egg-laying in our earlier soybean planting date study at Urbana, we decided nonetheless to sample western corn rootworm beetle population densities in soybean fields adjacent to problem cornfields. For comparison, soybean fields in the Champaign-Urbana area, where no reports of problems have been received, were also sampled.

Western corn rootworm beetle counts averaged 8.4 beetles per 100 sweeps in Champaign-Urbana soybean fields. In contrast, beetle counts in soybean fields near problem cornfields averaged 61.4 beetles per 100 sweeps. Although this does not prove that the greater abundance of rootworm adults in soybean fields near problem cornfields leads to greater egg-laying in these soybean fields, the results are intriguing nonetheless. The assumption that the egg-laying behavior of different populations of western corn rootworms in east-central Illinois is the same may have been incorrect.

Although problems with western corn rootworms at Piper City can be explained by pyrethroid use, other problem fields in east-central Illinois do not fit that pattern. It is possible that intense crop rotation in this part of the state may have selected for western corn rootworms that lay eggs in soybean fields. Whether pyrethroid use played a role in this process is open to question.

Eli Levine, Center for Economic Entomology

Photo by Eli Levine, INHS Center for Economic Entomology

Western corn rootworm beetle on corn tassel.

Plants of Site M, a True Macrosite

Most natural areas in Illinois are small, isolated, and surrounded by urbanized or agricultural lands. Resource managers face a daunting task trying to preserve the natural qualities of these areas.

To assist this process, the state is attempting to establish "macrosites"—large natural areas with unified management goals. Most macrosites consist of lands owned by several organizations or individuals, all of whom agree to manage their holdings for a common goal. But building such agreements can be difficult and time-consuming. Management is much easier if the entire macrosite belongs to a single owner.

Photo by Ken Robertson, INHS Center for Biodiversity

INHS researchers Geoff Levin (L) and Rick Phillippe (R) examine plants on a hill prairie at Site M.

One of the state's newest conservation and recreation areas is known as Site M. This area is in Cass County, about 30 miles from Springfield, and consists of almost 24.5 square miles in a single contiguous holding. Commonwealth Edison Company originally acquired the land for a coal-fired power plant and cooling lake, but decreasing electrical demand eliminated the need for such a facility. In 1993, Site M was purchased by the Illinois Department of Conservation.

The first step in developing management plans for Site M is a comprehensive inventory of the area's natural resources. We contracted to inventory the plants and found that although the land now has a single owner, its history of diverse ownership resulted in a mosaic of habitat types of widely varying natural quality. About half of Site M is cropland, much of which will be leased to farmers, thereby providing income to support the restoration and management of the rest of the area. Another 20% is pastureland. Cattle have been removed from most of Site M, but their impact is clear, not only on the former pastures but also throughout the area, including the forests that cover another third of Site M. Much of the forest had been partially logged, and with the grazing has resulted in woods that are dominated by small trees, such as hawthorns (*Crataegus* spp.), wild crab apples (*Malus* spp.), and Osage orange (*Maclura pomifera*); and by shrubs like raspberries, blackberries (*Rubus* spp.), and gooseberries (*Ribes missouriense*) that are unpalatable to cattle.

Still, there are patches of woods that, because of steep terrain, natural barriers like creeks, or the former owners' management, retain higher quality. These forests have a diversity of tree species and sizes, and a good diversity of spring woodland wildflowers. Other scientists have found that these areas are also home to rich birdlife and to the federally endangered Indiana bat (*Myotis sodalis*).

Botanically, the most significant vegetation type on Site M is hill prairie. Found on slopes that are too steep to cultivate, hill prairies require periodic burning to exclude trees and shrubs. The largest series at Site M is found in the Cox Creek Hill Prairie Natural Area. With restoration of adjacent pasturelands that appear to be former prairie, this area has the potential to become the largest hill prairie complex in the state. Although hill prairies account for less than 1% of the area of Site M, they are home to large populations of two threatened species in Illinois: Hill's thistle (*Cirsium hillii*) and pale false foxglove (*Agalinis skinneriana*). Site M hill prairies also contain Illinois' only known population of the state-endangered white lady's slipper orchid (*Cypripedium candidum*) surviving outside northeastern Illinois.

Two other state-threatened plant species are found at Site M. Two small populations of Nieuwland's blazing star (*Liatris scariosa* var. *nieuwlandii*) grow in highly disturbed forest edge sites. Much to our surprise, we also found several populations of large–seeded mercury (*Acalypha deamii*) along the floodplain and small tributaries of Cox Creek. Confined in Illinois mainly to the Wabash River drainage, this species had never been found so far northwest in the state.

With these inventories complete, the Department of Conservation can now develop management plans for Site M. Though degraded by logging, cultivation, and grazing, the forest and prairie habitats have the potential to be restored and enhanced. Plans are also under way to develop appropriate recreation opportunities like hiking, camping, hunting, and fishing. With its large size and diverse resources, Site M will be an ideal place to demonstrate the merits of macrosite management. This inventory also illustrates the ongoing cooperation among Illinois' natural resource-oriented agencies in meeting the state's conservation needs.

Geoffrey A. Levin, Loy R. Phillippe, and Kenneth R. Robertson, Center for Biodiversity

Insect legs are specialized for various functions. Study the two columns below and match the leg description with the insect that has that type of leg. There may be more than one answer for each insect.

Column 1

A. walking (cursorial)

B. grasping (raptorial)

C. swimming (natatorial)

D. digging (fossorial)

E. jumping (saltatorial)

Column 2

1

2

3

4

5

6

7

8

9

10

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Russian Wheat Aphids

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times as many arthropods were trapped in 1994, with one-quarter identified as aphids (600) and over half of those were RWA (339). RWA were abundant relatively high in the atmosphere especially on sunny days characterized by warm southerly winds. In the early morning of 6 June, 1994, RWA and other insects were collected throughout the lower atmosphere, including a number within a low-level jet blowing from the south at 22 m.p.h., about 2,200 ft. above the ground surface. Below the jet the atmosphere was stable, so it is likely that the insects we caught within these air layers were of local origin. However, if the insects that we found higher in the atmosphere had traveled in the low-level jet throughout the night, then they likely were immigrants from 150–250 miles further south, where large overwintering populations had been found in 1994. Samples from later the same day revealed that RWA were very abundant throughout the lower atmosphere. The highest altitude at which we caught RWA was approximately 5,000 ft. above ground level. RWA were not trapped in airstreams with temperatures below 54°F.

Other well-represented aphid species in the collections included small grain pests, such as the bird cherry-oat aphid, greenbug, and English grain aphid. The pea aphid, a prominent pest of alfalfa, was also present. Flies, wasps (mostly parasitic), leafhoppers and planthoppers, true bugs, spiders, a damselfly, a few small moths, thrips, mites, and many very small rocks were also trapped.

Photo by Gail Kampmeier, INHS Center for Economic Entomology

Mark Belding of the Water Survey calibrating on-board computer in helicopter used for RWA study.

Acknowledgments: The Colorado research team was led by Tom Holtzer, with Mark Carter, Ian MacRae, Tim Burton, and Chuck Lang (entomologists, Colorado State University), and student Derrick Nabel. Patrick Kennedy, Eugene Mueller, and Kenneth Pattison operated the CHILL radar. Monfort Inc., graciously donated the use of its aircraft support facilities for the field programs in both 1993 and 1994. We especially thank John Warrender, Ken Ferguson, and Matt Yakel for their tolerance and support of our activities.

Gail E. Kampmeier, Scott A. Isard, and Michael E. Irwin, Center for Economic Entomology

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ILLINOIS NATURAL HISTORY SURVEY

Reports

NATURAL HISTORY SURVEY

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Coyotes in Cornfields

Over the past few decades there has been a dramatic increase in the abundance of coyotes (*Canis latrans*) throughout the Midwest. As recently as the 1950s, coyotes were considered uncommon in Illinois; now there are probably over 30,000 living in the state. The reasons for the increase in abundance and expansion of the coyote's range over eastern North America are uncertain, but probably include the extirpation of competitors, such as gray and red wolves, from these areas.

Most people picture coyotes howling with the moonrise on some western desert landscape, not skulking around cornfields in central Illinois. In fact, coyotes flourish in a wide variety of habitats, but seem to prefer open environments. According to Don Hoffmeister in *Mammals of Illinois*, the early settlers called coyotes "prairie wolves" to distinguish them from the timber wolf, which occupied more densely wooded habitats. Only recently have coyotes become denizens of areas dominated by row-crop agriculture.

Photo courtesy U.S. Fish and Wildlife Service

*Coyote (*Canis latrans*) alive and well in Illinois.*

As recently as the 1950s, coyotes were considered uncommon in Illinois; now there are probably over 30,000 living in the state.

How has the coyote adapted to this new habitat? What characteristics have allowed it to become so successful in spite of intense hunting and trapping pressure? Although coyotes have been extensively studied elsewhere, surprisingly little research has been conducted on coyotes inhabiting agricultural landscapes. Does the behavior of coyotes living in these areas differ from that of coyotes in more "natural" habitats?

A pilot study is attempting to answer some of these questions by investigating home range size and habitat use of coyotes in central Illinois. Coyotes are captured using padded leg-hold traps, then fitted with collars and radio transmitters, and released. Their movements are then followed by telemetry.

Tracking radiocollared coyotes is not easy! Two researchers monitor the movements of individual coyotes from trucks outfitted with special antennae and receivers. The researchers communicate by CB radio and record simultaneous "fixes" (directional bearings of the strongest radio signal) to locate the coyote at frequent intervals throughout the night. Coyotes are very wary, so trackers must be stealthy as well in order not to spook their subject with bright headlights, loud noises, or truck engine ignition when changing tracking locations. Each animal is followed all night for at least six nights. Mostly, successful

Continued on back page

Flooding Effects on Urban and Community Trees

The Great Flood of 1993 will be remembered as one of America's most devastating natural disasters. Record high flows of floodwater breached over 1,100 levies and flooded communities up and down the Mississippi River and its tributaries. In the Mississippi River Basin, flooding covered 10 million acres, destroying or damaging more than 40,000 buildings and killing at least 47 people. Much of the attention to the flood was focused on the loss of buildings, roads, and crops. A factor that is hard to calculate into flood loss is the mortality of community trees.

Photo by Fredric D. Miller, Affiliate, INHS Center for Economic Entomology

Strong water currents washed away soil around the base of trees, exposing the roots.

There is considerable information available on the survival of trees that are subjected to flooding during the dormant season or for relatively short periods during the spring. These studies indicate the response to flooding depends upon the season, depth, and duration of flooding, and the age and health of the tree species affected. Prolonged late-season flooding, like that in 1993, has not been thoroughly examined.

Unlike native stands of timber along rivers that have an evolutionary history of surviving floods, community trees are typically transplanted from nurseries and may or may not be native to the area where they are growing. The flood provided a unique opportunity to research the effects of long-term, late-season flooding on trees in urban and community settings.

A research project to examine the immediate and long-term effects of the flood on urban trees was initiated in fall of 1993 as a collaborative effort among scientists at the Illinois Natural History Survey, the University of Illinois, Western Illinois University, and the University of Northern Iowa with cooperation from the U.S. Army Corps of Engineers and the city of Davenport, Iowa, and other flood-affected communities. The goals of the project represent the various interests of the scientists involved. Our foremost objective is to determine the "urban" tree species most susceptible to prolonged late-season flooding. Secondarily, we are interested in determining the cause of mortality in years following the flood.

Unlike crop plants, mortality related to the flood will continue for several years in long-lived plants, such as trees. Flooding saturates the soil and rapidly depletes oxygen available to roots in the soil. When flooding occurs, the soil has less oxygen for root respiration, and the conditions become anaerobic. Anaerobic respiration produces compounds that are toxic to roots. Water and nutrient-absorbing roots die, creating a void in the nutrient cycle of the trees that results in less photosynthesis. Eventually, if conditions don't change, the trees may die. Root mortality caused by the flooded soils will continue after the water has receded, making the trees susceptible to various secondary pests.

Trees may succumb to diseases or insect attacks in years following the flood due to the stress of flooding. Determining what diseases and insects are attacking these stressed trees and which trees are less likely to be attacked is another significant aspect of the project.

Flooded and nonflooded sites in close proximity were selected for our studies. Trees in the flooded sites were submerged in water 5 to 6 feet deep for periods up to six weeks during the growing season in 1993. Preliminary "urban" tree inventories were taken of the study sites in 1994. Tree

Continued on next page

Flooding Effects

continued from previous page

species and flood-related tree mortality were recorded along with diameter (growth) measurements and tree condition ratings of the living trees. Inventories of the trees will continue through 1998.

Early observations show heavy first-year mortality of sugar maple, crabapple, hackberry, ornamental pear, linden, eastern white pine, junipers, and other evergreens. Limited mortality was observed in pin oaks and walnuts. Rot and decay fungi were identified on dead trees but were not implicated in causing mortality. Similarly, bark beetles and other insects that feed in dead wood were identified on many of the dead trees, but were not implicated in the trees' demise.

Initial inventories were provided to the affected communities to assist them in replanting and replacing plant materials damaged in the flood. The information gained from the studies will assist landscapers and communities in using flood-tolerant plantings in flood-prone areas. It will also give us a better understanding of insect, disease, and tree interactions associated with flooding stress on tree species not adapted to that environment.

John E. Lloyd and Fredric D. Miller, Center for Economic Entomology; Patrick J. Weicherding, Department of Forestry, University of Illinois

Photo by Fredric D. Miller, Affiliate, INHS Center for Economic Entomology

Many trees were killed by the flood in 1993. The overall influence of the flood on tree survival will be seen in years to come.

New Version of an Old Classic

In 1934, the Survey published a circular by H. H. Ross entitled *How to Collect and Preserve Insects*. The circular's intent was to show how easy it was to make a start in insect collecting and to give the collector an idea on how and where to begin. This popular circular was revised once and reprinted eight times. Because of its popularity, supplies of the last printing were exhausted in 1984.

The circular has been revised and updated again and will soon be back in print. The revised publication highlights basic information about collecting techniques, collecting equipment, preservation techniques, classifying and naming of organisms, and it contains a synopsis of the insect orders.

Collecting insects is one of the best ways for people to learn about the diversity and abundance of insects. There are an estimated 1 million species known at the moment and probably 10 times that number still remaining to be identified.

Many people enjoy collecting and derive satisfaction from subsequently organizing and displaying specimens. On a practical level, collections of beneficial insects and of household and garden pests can be used by farmers, homeowners, and pest control operators to help them recognize these insects.

The newest *How to Collect and Preserve Insects* manual, now called "INHS Special Publication 17," was co-authored by INHS Insect Collection Manager Kathleen R. Methven, entomologists Michael R. Jeffords and Richard A. Weinzierl, and former Insect Collection Manager Kathryn C. McGiffen. The manual contains 76 pages and is spiral-bound for easy use. It will be available soon through the INHS Publications Office for $6.

The cover of INHS Special Publication 17.

Kathleen R. Methven, Center for Biodiversity

Illinois Wetland Conservation Strategy

Part land, part water, wetlands represent a unique habitat. In general, wetlands are defined as transitional areas between open water and upland, and they are an integral and dynamic component of our landscape.

Photo by Michael Jeffords, INHS Center for Economic Entomology

A typical bog with carnivorous pitcher plants in the foreground.

Wetlands serve a multitude of functions that are crucial to establishing environmental balance and human well-being. Wetlands are valuable in terms of reducing flood damage, contributing to groundwater and surface water recharge, improving water quality, and supporting habitat for fish and wildlife, as well as providing educational, recreational, and research opportunities.

Recent studies indicate that the nation has lost more than half of the wetlands that existed in the contiguous United States since European settlement began. Illinois has the dubious distinction of being the sixth highest state in terms of percent wetlands lost.

An estimate of presettlement wetlands for Illinois is 9,412,659 acres. The most recent inventory of wetlands in Illinois reveals that approximately 917,765 acres of natural wetlands remain, of which only 5,000 acres are undisturbed. Thus, Illinois has lost over 90% of its original wetland acreage. Wetland types in Illinois include bogs, fens, marshes, seeps, springs, and shallow ponds.

Activities contributing to wetland loss or degradation in Illinois include urban development, agricultural activities, forestry practices, channelization, pollution, sedimentation, and the introduction and invasion of nonnative species.

Over the past several years, the U.S. has devised various public and private programs to protect and manage this valuable resource. Unfortunately, many of these programs have addressed only limited aspects of the wetlands protection problem. In 1987, The Conservation Foundation convened the National Wetlands Policy forum. This diverse group reached a consensus on over 100 recommendations for improving wetlands protection. To translate these recommendations into action, the forum concentrated on states and encouraged them to take the lead in wetlands protection by developing comprehensive programs to achieve no net loss of wetlands.

The development of a wetlands conservation plan is currently under way in Illinois. The Illinois Wetlands Conservation Strategy (IWCS) is a comprehensive plan to guide the development and implementation of Illinois' wetland programs and wetland protection initiatives. The IWCS is an organizational tool used to identify opportunities for making programs work better.

This effort will encompass the guidelines provided by Governor Edgar's Water Resources and Land Use Priorities Task Force, the Interagency Wetlands Policy Act of 1989, Conservation Congress, and the Illinois Department of Conservation's Strategic Planning Process.

Development of the IWCS is a collaborative process involving Sharon Baum of the Illinois Natural History Survey, Marvin Hubbell of the Illinois Department of Conservation, the Interagency Wetlands Committee, and the public Wetlands Advisory Group.

The Interagency Wetlands Committee consists of representatives from nine state governmental agencies that deal with wetlands-related issues. The committee was established by the Interagency Wetlands Policy Act of 1989.

In order to have a successful planning process, input from the public is essential. The public Wetlands Advisory Group was established specifically for assistance with the development of the IWCS. The Wetlands Advisory Group, which consists of 190

Continued on next page

Wetland Strategy

continued from previous page

members, represents diverse interests, including agriculture and other industries, environmental organizations, sportsmen, residential developers, utilities, scientists, and all units of government.

The goal of the IWCS is to ensure that there will be no overall net loss of wetlands or their functional value in Illinois. The objective of the IWCS is to develop and implement an ecosystem-based strategy for the stewardship, protection, restoration, enhancement, and management of Illinois' wetlands.

Communication with the Wetlands Advisory Group is conducted mostly through the mail. The Wetlands Advisory Group receives bi-monthly mailings, which its members review and comment on prior to the next mailing. Public meetings with members from the Wetlands Advisory Group were held in March 1995. Additional meetings are being scheduled for this August.

The Interagency Wetlands Committee meets monthly to discuss many wetlands-related issues and to review the progress of the IWCS. Marvin Hubbell, chairman of the Interagency Wetlands Committee, reports on the progress of the committee and IWCS to the Natural Resources Coordinating Council. This council was appointed by Governor Edgar and is officially responsible for developing comprehensive recommendations for land and water conservation. All departments within the Illinois Department of Conservation also review progress on the IWCS.

The information contained in the mailings for the public Wetlands Advisory Group pertains to 18 wetlands-related issues that the group prioritized in May 1994. For each issue, the Wetlands Advisory Group identifies (1) major items related to the issue, (2) recommendations to solve the problem, (3) impediments to solving the problem, and (4) how the IWCS can help to address the issue. A few examples of the 18 wetlands-related issues include floodplain policy, status of the wetland resource, drainage law, private property rights, and educational/outreach programs.

The Wetlands Advisory Group, Interagency Wetlands Committee, and all departments within the Illinois Department of Conservation will review all drafts of the IWCS. Upon completion, the IWCS and its recommendations will be sent to the Natural Resources Coordinating Council, the Office of the Governor, the Illinois House and Senate Committees, the state's congressional delegation, and U.S. Senators representing Illinois.

Sharon Baum, Center for Wildlife Ecology

Photo by Michael Jeffords, INHS Center for Economic Entomology

Two sliders enjoying a sunny log in an Illinois wetland.

IMPORTANT NOTE

Effective July 1, 1995, the price of Survey publications published after July 1, 1995, will be increased as follows:

Survey Reports	Free
Bulletins	$10.00
Biological Notes	$4.00
Circulars	Discontinued
Special Publications	Priced individually

The price of Survey publications published piror to July 1, 1995, will remain as follows:

Survey Reports	Free
Bulletins	$4.00
Biological Notes	$3.00
Circulars	$3.00
Special Publications	Priced individually

Species Spotlight

Green Tiger Beetles

Susan Post

With the sun shining off its iridescent blue-green elytra, the green tiger beetle resembles an emerald lost on a sandy path. A closer inspection usually reveals nothing but sand because the "emerald" has flown several feet down the path. The scenario is repeated until the beetle tires of the "game" and flies off. From early spring until fall, many species of tiger beetles may be found in open sunny habitats—roads, paths, beaches, and mud flats—and always one or two steps ahead of the observer.

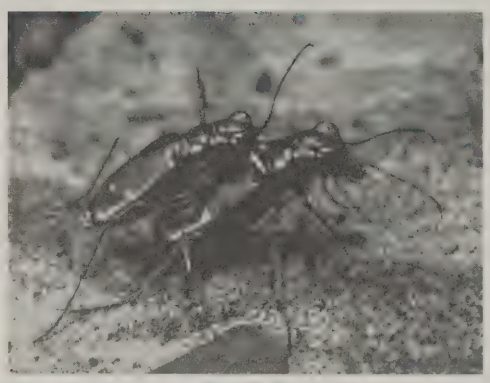

Photo by Michael Jeffords, INRS Center for Economic Entomology

Green Tiger Beetles (Cincindela sexguttata) in the act of mating.

Green tiger beetle adults are slender predatory beetles with long legs, large eyes, and thread-like antennae. Like all chewing insects, they have a pair of mandibles. Mandibles in general are powerful grinding jaws that are lined with teeth and work sideways instead of up and down like a human's. The tiger beetle's mandibles are sickle-shaped and very sharp, with several teeth on the inner face. The name tiger beetle refers to its predaceous habits (both adults and larvae eat all kinds of insects) and to the ability of the adults to suddenly pounce on their prey.

During the summer months females will deposit their eggs in sandy soil. The eggs become larvae that are whitish, S-shaped, and grub-like with long curving jaws and large hard heads. The larvae prop themselves up in their vertical burrows with their oddly-shaped heads often plugging the burrow entrance. They wait with open mandibles for a hapless victim, which they seize and take to the bottom of the burrow (sometimes a foot below the surface) to devour at their leisure. On the larva's fifth abdominal segment is a spine that anchors it to the side of the burrow. Thus, if a larva grabs an insect that is too large to overcome, it is anchored to the burrow and will not be pulled out.

Tiger beetle larvae also have enemies. Sometimes the larvae are attacked in their burrows by a small wasp that will sting and paralyze them. The wasp then proceeds to lay its eggs on the larvae and seals the burrows. The young wasps feed on the beetle larvae as they develop.

The tiger beetle sheds its exoskeleton three times in order to grow larger. Prior to each molt the tiger beetle larva must undertake an extra step and enlarge its burrow to accommodate its soon-to-be bulkier self. Pupation takes place in a chamber dug off the main tunnel and the entire life cycle will take up to three years.

Teacher's Guide to "The Naturalist's Apprentice" (facing page)

The Food Web Story

Objective: students learn some of the relationships within a food web

Materials: multiple copies of **The Food Web Story**

Vocabulary: carnivore, decomposer, detritivore, herbivore, omnivore, primary producer

Comments: When scientists study the structure and functioning of food webs, they use specific terms to describe the relationships between various organisms. Plants are called primary producers because they absorb the energy of sunlight and convert it into food for other organisms. Organisms that eat green plants are called herbivores, and those that eat other animals are called carnivores. Organisms that feed on a great variety of organisms, both plant and animal, are called omnivores. Organisms that rely on dead animals or plant material are called detritivores or decomposers. All of these eat-or-be-eaten relationships make up a food web.

Procedure:

1. Explain the above material and distribute copies of **The Food Web Story** to students. Ask students to read the story and to place the organisms discussed in the story in the proper categories.

2. As an extension of this activity, have students draw or find pictures of the organisms mentioned in the story and construct a food web.

3. Students draw arrows between organisms that are directly related in the food web (eat or are eaten). Arrows should always point in the direction of energy flow. For example, the flea bites the deer, the flea takes energy from the deer: deer———>flea.

4. Discuss the complete food web and the role each organism plays. Which category of organisms are the most numerous? Which are the heaviest (have the greatest biomass)? What happens if some of the organisms are removed from the ecosystem?

The Food Web Story

Michael Jeffords

The Food Web Story

Read the story below and match each organism mentioned with one of the five categories below. You may also wish to make a sketch of the entire food web.

On a bright spring day the sun shines onto the forest floor. The warm weather and the moist soil cause plants to sprout. Up through the dead and decomposing leaves (humus) come spring beauties, larkspurs, and other spring flowers. The old oak trees unfold their new leaves, and within a matter of days the leaves begin to produce food by photosynthesis. Mushrooms pop up around rotting logs, and beetle larvae feast on the fungus and decayed wood. Soon the spring warmth triggers the hatching of linden looper caterpillar eggs, and these young caterpillars crawl onto the tender oak leaves and begin feeding. The new tree and understory foliage allow a female deer to eat well; in turn, she provides food to her fawn in the form of milk. The doe rubs her leg against a rough tree because a flea has just bitten her.

Earthworms tunnel through the moist earth, leaving behind little piles of soil in which wildflower seeds will sprout. Aphids find the young oak leaves juicy and nourishing. The aphids stick their needlelike mouth parts into the oak's stems and suck its juice. A bright green tiger beetle walks along sunny forest paths searching for its dinner—linden looper larvae that have fallen off the oak foliage. Elsewhere, spiders spin webs to catch unsuspecting insects like midges and young grasshoppers.

Another inhabitant of the forest, a white-footed mouse, comes out and searches for food—wild-flower seeds, mushrooms, acorns, and any caterpillars it finds. Grackles and robins begin courtship and will soon feed caterpillars and earthworms to their young in the nests in the oaks. Linden looper caterpillars have other enemies besides the birds and beetles. A tiny wasp parasite lays her eggs on the caterpillar and the young wasp will feed on it (from the inside out!) until fully grown. As the season progresses, the young birds and mice must be wary of owls and hawks, the deer and fawn wary of the hunter . . . .

Which of the organisms mentioned in the above story are:

Primary Producers

Herbivores

Carnivores

Omnivores

Detritivores

"The Naturalist's Apprentice" presents educational activities for middle school students. Teachers are invited to photocopy this page for classroom use.

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Coyotes in Cornfields

continued from front page

radiotracking requires luck, patience, and lots of coffee.

Only two coyotes were radiotracked in the late summer of 1994. One of these was an adult male and the other was a subadult male, a coyote "teenager." The adult male had a home range covering about 13 square miles, and the subadult ranged over 39 square miles during July and August. These home ranges are very large compared to similar measurements reported from other habitats. For example, home ranges of coyotes in the western U.S. average about 6 square miles. Six more coyotes were radiocollared in March and April 1995 and are currently being radiotracked.

In addition to measures of home range size, habitat use will be determined by plotting locations of animals made at hourly intervals onto aerial photos of their home ranges. Understanding how coyotes use the landscape while hunting or traveling can provide insights into how they interact with other carnivores and prey species that might be concentrated in habitat features, such as hedgerows, fence lines, grassy strips, or small woodlots. If prey species become concentrated in areas

Photo by R.H. Barrett, American Society of Mammalogists

Illinois' largest predator hot on the trail of a potential meal.

that are used heavily by coyotes, these areas may act as "ecological traps." Prey species might be attracted to such areas because of apparently suitable cover or food resources but be exposed to greater risk of predation than if they spread out into other habitats.

The results of this study will help us design future, more detailed studies of the ecology of coyotes in agricultural landscapes. With luck, patience, and a continuous supply of coffee, we'll learn more about the secretive habits of Illinois' largest extant predator.

Ed Heske, Center for Wildlife Ecology, and Marty Miller, Department of Forestry, University of Illinois

Illinois Natural History Survey Reports is published bimonthly by the Illinois Natural History Survey, 607 East Peabody Drive, Champaign, IL 61820 Headquartered on the campus of the University of Illinois at Urbana-Champaign, the Survey is a division of the Illinois Department of Energy and Natural Resources

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ILLINOIS NATURAL HISTORY SURVEY

Reports

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INSIDE

Pearly Eyes in Illinois

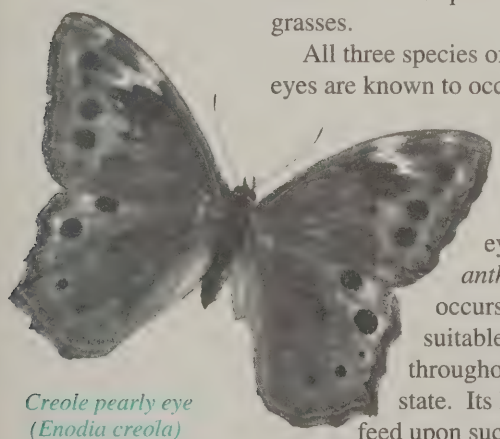
The mention of butterflies usually brings to mind the image of brightly colored creatures sipping nectar at midday from equally brightly colored blossoms in sunny meadows or gardens. However, a small, exclusively North American genus (*Enodia*) of drably colored butterflies known as pearly eyes does not fit this popular conception. The three species of pearly eyes are forest insects, and their flight activity is generally at dawn and at dusk. At midday they often perch high on tree trunks where they are wary and difficult to approach.

Pearly eyes do not visit flowers; rather, they imbibe fluids from bird excrement, decaying animal flesh, and sap that flows from wounds on trees. The larval stages of these butterflies feed upon coarse grasses.

All three species of pearly eyes are known to occur in Illinois. The northern pearly eye, *Enodia anthedon*, occurs in suitable habitat throughout the state. Its larvae feed upon such forest grasses as broadleaf uniola and bottlebrush. The other two species—pearly eye, *Enodia portlandia*, and Creole pearly eye, *Enodia creola* —occur in a few counties of southern Illinois where their larval host, giant cane, grows. Long confused with the northern pearly eye because of their extreme similarity in appearance, the Creole pearly eye and pearly eye are considered rare and little-known. Perhaps due to the somberly drab coloration of these butterflies, they are little noticed in the dappled shade of their gloomy riverine haunts.

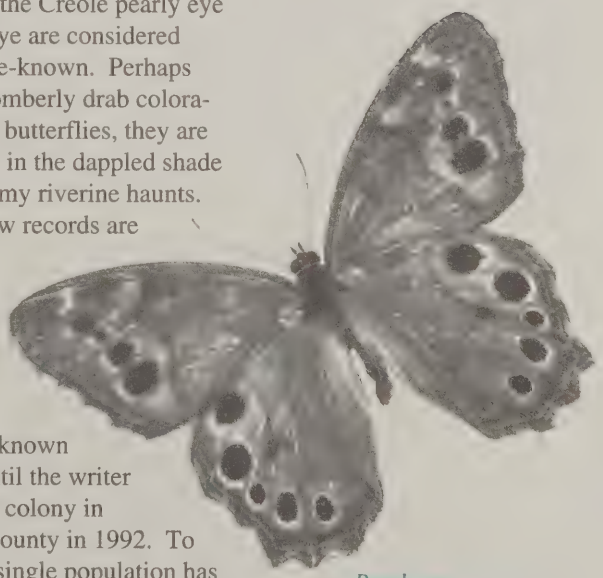
Photos by Douglas Yanega, INHS Center for Economic Entomology

Northern pearly eye (Enodia anthedon)



Creole pearly eye (Enodia creola)

Only a few records are available for the Creole pearly eye in Illinois, and the pearly eye remained unknown in Illinois until the writer discovered a colony in Alexander County in 1992. To date, only a single population has been located, but a search to discover additional populations of this rare denizen of our southern forests continues.



Pearly eye (Enodia portlandia)

John K. Bouseman,
Center for Economic Entomology

Governmental Reorganization

On July 1, 1995, a major reorganization or consolidation of some departments of the State of Illinois was realized. This reorganization has its foundation in an Executive Order issued by Governor Jim Edgar on March 1, 1995. A new Department of Natural Resources (DNR) was formed to strengthen the state's ability to protect, enhance, and responsibly use Illinois' natural resources in order to provide the citizens of today and tomorrow with an outstanding quality of life. At the same time, it is expected that the reorganization will result in programmatic and administrative efficiencies.

The DNR contains the former Department of Conservation, the former Department of Mines and Minerals, the former Abandoned Mined Lands Reclamation Council, the Division of Water Resources of the Department of Transportation, and portions of the Department of Energy and Natural Resources (DENR). Those parts of DENR transferred to DNR include the Illinois Natural History Survey (INHS), the State Geological Survey, the State Water Survey, the Illinois State Museum, the Hazardous Waste Research and Information Center (HWRIC), and the Office of Research and Planning.

The Department of Natural Resources is led by Director Brent Manning and Deputy Directors John Comerio and Bruce Clay. Internally, the Department will be organized into 10 functional offices, one of which, the Office of Scientific Research Analysis, will contain the three Surveys, the State Museum, and the HWRIC. This Office will be headed by Assistant to the Director for Scientific Research and Integration, Karen A. Witter, erstwhile Director of the Department of Energy and Natural Resources from 1988 to 1991. Since 1991, Karen served as the Executive Director of the Governor's Science Advisory Committee.

ILLINOIS DEPARTMENT OF NATURAL RESOURCES

Some readers may recall reading in INHS' Annual Report for 1991-1992 that I reported on an attempt to dissolve the Department of Energy and Natural Resources and to find new homes for the divisions in various state agencies or in the University of Illinois. A number of different options were explored in this effort and ultimately failed because of the concerns of the constituency and clients of the Surveys, HWRIC, the State Museum, and others. Their concerns, and ours, focused primarily on the need to maintain our ability to produce credible science. Of special concern was the possible placement in an agency with broad regulatory and enforcement powers that might attempt to influence the independence of our research in order to support regulations.

During the process of defining the reorganization, we were given assurances, from all significant levels of state government, that the concerns expressed during the earlier reorganization effort would be satisfactorily met. Undoubtedly, there will be many changes in store for INHS, but the bottom-line integrity of our science will be preserved.

The Board of Natural Resources and Conservation, founded by statute in 1917, will remain intact together with its duties including the oversight function of the three Surveys and HWRIC. The Board of the Illinois State Museum also will remain intact, together with its duties.

Continued on page 5

Survey Ecologist Advises President's Council on Sustainable Development

In June 1993, President Clinton created the President's Council on Sustainable Development (PCSD). Composed of 25 leaders from industry and government, and representatives of environmental, labor, and civil rights organizations, the PCSD is charged with preparing a national sustainable development action strategy and with advising the President on matters related to sustainable development.

The sustainable development initiative will detail how the U.S. may provide its citizens, now and in the future, a high-quality life by maintaining ecosystems that provide renewable natural resources and natural services. The ecosystems include agricultural fields, forests, grasslands, wetlands, lakes, rivers, streams, and oceanic and coastal systems. The services these ecosystems provide include production of food, fuel, and materials (including yet-to-be-discovered raw materials for molecular engineering); moderation of floods and erosion; water purification; aesthetic values; outdoor recreation; and preservation of both biodiversity and the processes that generate it.

The work of the Council is accomplished primarily through eight task forces. These include Principles, Goals, and Definitions; Public Linkage, Dialogue, and Education; Population and Consumption; Sustainable Agriculture; Sustainable Communities; Eco-Efficiency; Energy and Transportation; and Natural Resources. The Natural Resources Task Force is developing an integrated vision of what constitutes sustainability for natural resources in the areas of biodiversity, ecosystems, and watersheds, with a focus on issues regarding wetlands, fisheries, agriculture, coastal resources, and forestry. The Task Force is using a process of discovery, employing 14 watershed workshops throughout the country to develop policies to foster, catalyze, and remove impediments to protection and sustainable management of natural resources.

The Natural Resources Task Force also receives advice and information from regional advisory committees. Illinois Natural History Survey aquatic ecologist Richard E. Sparks serves on the Midwest Regional Advisory Committee, which met three times and has submitted information and recommendations to the Task Force. He also served on a National Research Council Committee of the National Academy of Sciences that provided technical advice on a watershed approach to sustainable use and development of natural resources.

The Midwest Advisory Committee held its first meeting at La Crosse, Wisconsin, in July 1994 in association with the International Conference on Sustaining the Ecological Integrity of Large Floodplain Rivers. Two members of the Natural Resources Task Force were also present for special briefings by river scientists and managers from Europe and North America. These scientists discussed effects of river development on ecosystem integrity and the relationship between floodplain development and flood damages in the 1993 Midwest Flood and the 1993-1994 floods in western Europe.

At the November meeting in Des Moines, Iowa, the Advisory Committee heard from agribusinesses, levee district associations, the navigation industry, farm groups, and state land and water resource managers about the implications of world trade agreements (GATT and NAFTA) for the economies and ecosystems of the Midwest. Chief among the environmental concerns associated with expanded trade is an expected rise in the introduction of nonindigenous pests, including vectors for human diseases.

The final meeting of the Midwest Advisory Committee was in January 1995 in Baton Rouge, Louisiana, where state agencies, private timber companies, and en-

Continued on back page

Photo by Thomas Rice, INHS Publications Office

Wetlands near the Kankakee River that exemplify an ecosystem important for sustainable development in the state.

Tree Cavity Abundance and Use by Nesting Wood Ducks

At the turn of the century, the wood duck (*Aix sponsa*) was considered by many to be on the brink of extinction, and as a result, wood ducks were granted full protection during the 1916-1940 waterfowl hunting seasons. However, the comeback of the wood duck to current abundant population levels rivals that of the white-tailed deer, giant Canada goose, and the wild turkey.

In recent years, wood ducks have been the most common nesting duck in Illinois. Wood ducks also currently rank second in the number of ducks harvested in Illinois and have been second in the harvest of ducks in the Mississippi Flyway for most of the last 33 years. Although wood duck populations in Illinois, the Mississippi Flyway, and the Atlantic Flyway appear to be increasing, little is known of wood duck production and use of natural tree cavities in Illinois. No recent studies have determined the importance of natural tree cavities for nesting wood ducks in Illinois.

Wood duck
*(*Aix sponsa*)*

A major problem in wood duck management has been the inability to estimate the size of populations because of the species inhabitation of densely forested areas and its secretive nature. Estimation of wood duck population size and trends has been an important management goal in Illinois and the Mississippi Flyway because aerial surveys of this species have proven inadequate. In 1993, states in the Atlantic and Mississippi flyways, along with the U.S. Fish and Wildlife Service, developed a wood duck management strategy to outline databases needed to effectively manage wood duck populations. One specific objective of this strategy was to develop techniques that would provide estimates of regional breeding population sizes. Therefore, information on the size of the regional wood duck breeding population was necessary to enhance management of this species endemic to North America.

Our study on the abundance of natural cavities suitable for nesting by wood ducks, their nesting use by wood ducks, and success of the nests was an important step in estimating wood duck population size and growth in Illinois.

The study area encompassed portions of southwest Mason, northwest Cass, and eastern Schuyler counties and included 3,835 ha (ha = hectare, which = 2.5 acres) of the state-owned Sanganois Conservation Area. Sanganois is a floodplain forest at the confluence of the Illinois and Sangamon rivers and is considered to be one of the least disturbed bottomland areas along the Illinois River.

Cavity densities suitable for wood duck nesting at Sanganois were 2.12 cavities per ha, or an estimated total of 4,577 natural cavities in the 2,159 ha of forested wetland habitat on the study area. Eighty cavities were inspected for wood duck use during July 1994. Ten (12.5%) cavities were used for nesting by wood ducks yielding a wood duck nest density at Sanganois of 0.206 nests/ha. Of the 10 wood duck nests located in natural cavities, five were destroyed by raccoons, three hatched successfully, one was abandoned for unknown reasons, and the fate of one nest could not be determined. Thus, a simple estimate of nest success in natural cavities was 33.3%.

The density of cavities suitable for nesting by wood ducks at Sanganois was relatively high when compared with other studies. Only three previously reported surveys indicated higher

Continued on next page

Wood Ducks

continued from previous page

densities of natural cavities. Studies in New York, Minnesota, and New Brunswick reported 3.95 - 5.50 suitable cavities/ha of forested habitat. As expected, suitable cavity densities at Sanganois (2.12 cavities/ha) were more comparable with densities found in Indiana (1.23 cavities/ha) and Kentucky (1.26 cavities/ha) because cavity densities tend to be greater in the northern states than in the southern states. Also, tree species prone to cavity formation in the north are less common in the south, and tree injuries heal more quickly in the southern states, thereby reducing cavity formation rates. Cavity densities in other geographic regions ranged from 0.075 to 0.67 cavities/ha.

A wood duck natural cavity survey of bottomland forest near Sanganois in 1944 revealed 0.15 suitable cavities/ha. Upland black oak woodlots in central Illinois contained 0.51 suitable wood duck nesting cavities/ha during 1938-1961. These previous surveys in central Illinois revealed much lower densities of cavities suitable for nesting by wood ducks than our survey indicated. The increased density of natural cavities along the Illinois River probably represented the increased age and maturity of the forest stand along with a change in the bottomland forest composition to better cavity producing tree species, such as silver maple and black willow.

Photo by Steve Havera, INHS Center for Wildlife Ecology

Tree cavity used by wood ducks for nest.

Continued monitoring of natural cavities at Sanganois during summer 1995 will provide more information on the importance of natural cavities for nesting wood ducks in Illinois River bottomlands.

Aaron P. Yetter, Christopher S. Hine, and Stephen P. Havera, Center for Wildlife Ecology

Reorganization

continued from page 2

The formation of the Department of Natural Resources comes at a most opportune time for several reasons. First, federal environmental law is being undermined by eliminating or reducing the appropriations that underpin the law in the interest of reducing the deficit. In some instances, the law is, or will be, directly attacked during the reauthorization process based on special interests rather than informed science. Because of a series of special reports and the support of the Conservation Congress, Illinois is in a stronger position than virtually any other state to provide the advice and options necessary to play an influential role in the national debate. Secondly, the old Department of Conservation was actively involved in a number of projects that could bring significant lands under partnership management in the near future. These macrosites offer unparalleled opportunities for the application of ecosystem management techniques and for making a positive impact on behalf of biodiversity. We are looking forward to the exciting opportunity and synergism of collaborating with others in planning the macrosites.

We intend to continue the publication of *Survey Reports* and to provide it free-of-charge to interested readers. *Survey Reports* may also be found in electronic format:
http://www.inhs.uiuc.edu/chf/pub/surveyreports/sr-index.html

Lorin I. Nevling
Chief, Illinois Natural History Survey

Species Spotlight

Plains Pocket Gopher

Susan Post

The plains pocket gopher (*Geomys bursarius*), the only gopher that lives in Illinois, is named for its fur-lined pockets, one under each jawbone, that carry food and nest materials.

In Illinois, the plains pocket gopher is found just east of the Mississippi River in St. Clair and Madison counties, then east and south of the Illinois River to its junction with the Kankakee River, and south of the Kankakee to the Indiana state line. Large rivers, like the Mississippi and Illinois, appear to be barriers to its distribution. The gophers inhabit areas where the soil is well-drained and there's an abundance of tuberous-rooted plants.

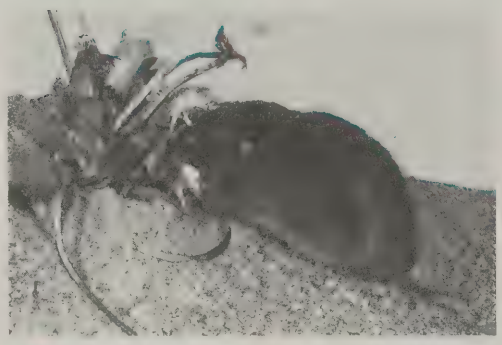


Photo by Michael Jeffords, INHS Center for Economic Entomology

Plains pocket gopher (Geomys bursarius) *stuffing its pockets with a snack.*

It is generally said that a pocket gopher's coat is the same color as the soil in which it lives. The Illinois population is unique among pocket gophers in the middle U. S., however, because its members are all black, regardless of the soil type they inhabit. Only the nose, feet, and the terminal half of the tail are white.

Gophers have large forefeet with five strongly-clawed toes to aid in digging and pushing dirt from the tunnel. Their toes are lined with bristles that may assist in moving dirt. The tail is bare near the tip to serve as a "feeler" when the animal backs up in the burrow. Pocket gophers can run backward almost as swiftly as forward. A unique adaptation allows the mouth to be closed behind the incisors; thus, these teeth can be used in the digging process. Gopher skin is loose and easily stretched, allowing the animal to readily reverse itself via a somersault in its narrow burrow.

The plains pocket gopher constructs underground burrows in which it spends nearly all of its life. With its front paws at either side of its face, the gopher shoves the dirt out of the tunnel, much like a small bulldozer. When the gopher is finished, the exit is plugged with tamped soil. Although the tunnels may be long, they are only 1.5 to 3 inches in diameter, just large enough for the gopher to get through. Each burrow includes a main nest, toilet chamber, and many food storage chambers. Here the gopher stores a variety of vegetable matter from roots, tubers, stems, and leaves—most any herb will do. Unlike the mole, pocket gophers are vegetarians and all of the many insects and other arthropods that may share its burrow are safe. Plains pocket gophers are solitary except during the breeding season.

Only a single litter is produced each year and one to six young are born between early March and early May. A newborn gopher is a fat, stubby creature with short legs and a tail; its naked dark skin appears to be too big and hangs loosely in many wrinkles and folds. The eyes and ears are sealed shut. By five weeks the eyes open and within two months the young gophers are on their own, building tunnels, working and reworking the soil—nature's bulldozers.

Teacher's Guide to "The Naturalist's Apprentice" (facing page)

Illinois Mammal Facts

Objective: students are exposed to the diversity of Illinois mammals and to facts about selected species

Materials: multiple copies of **Illinois Mammal Facts**

Vocabulary: badger(s), carnivore, endangered, habitats, herbivores, insects, opossum, predators, woodchuck

Comments: While low in relative number of species, 67 to be exact, the mammals of Illinois are certainly some of the most well-known inhabitants of the state. Mammals can have profound effects upon the landscape by their many activities, such as selective feeding on plants; tunneling through the leaf litter in forests, which helps to retard runoff and prevent flooding; and consuming large numbers of undesirable organisms, particularly insects. Perhaps their most useful value, though, particularly in a state that has been extensively developed, is an aesthetic one. An ever-increasing number of people travel throughout Illinois to catch glimpses of wild animals in their native habitats. Wildlife sitings may be as simple as seeing a family of raccoons traipsing across your suburban front yard at dusk, or as complex as viewing the interactions of male white-tailed deer during the rut each fall. But whether the siting is of an elusive bobcat in the Shawnee Hills, the small brown blur of a white-footed mouse in an old field, or the nightly travels of bats at dusk, each siting is unique and contributes to our appreciation of wild Illinois.

Procedure:

1. Introduce the subject of Illinois mammals and have students name as many species of Illinois mammals as they can.

2. Distribute copies of **Illinois Mammal Facts** and have students complete the exercise. *Answers: habitats, herbivores, opossum, predators, insects, southern, woodchuck, carnivore, badger—badgers, endangered*

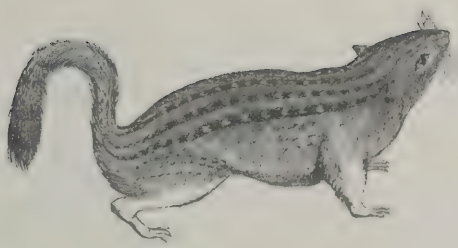
3. Have groups of students come up with their own puzzles and exchange them with other groups.

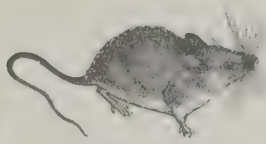
The Naturalist's Apprentice

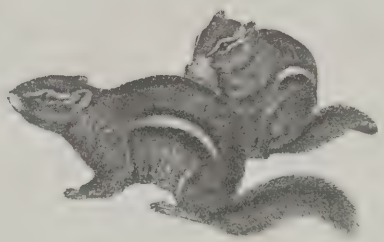
Illinois Mammal Facts

Michael Jeffords

Study the statements below and unscramble the word found in each sentence. Write that word in the blank following each statement.







1. Although mammals can be found throughout Illinois, many species have particular places, called TTAABISH, where they prefer to live._____

2. Those species of mammals that are RVHERSEBIO seldom need to travel very far in search of food._____

3. The UOSMOSP is the only member of its order found in Illinois. Most of its relatives live in Australia._____

4. Among the most voracious of RORDASTPE are the shrews. Some species eat three times their own weight every 24 hours!_____

5. Little brown bats feed only on SSCTNEI._____

6. Swamp rabbits are rare in Illinois and occur only in far NUETSOHR Illinois._____

7. The OKHUOWDCC is a burrowing, gnawing rodent that eats mostly plants, including certain field crops, such as clover, alfalfa, and soybeans._____

8. The gray fox can climb trees and is primarily a VACEINRRO._____

9. During most of the year, the home of the EDRBGA is a shallow burrow. SERDBGA only eat other animals._____ _____

10. The bobcat is GAEDNEEDRN in Illinois. This cat prefers a habitat of heavy forest cover with much underbrush broken by clearings and rocky outcrops. _____

"The Naturalist's Apprentice" presents educational activities for middle school students. Teachers are invited to photocopy this page for classroom use.

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ILLINOIS
DEPARTMENT OF
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RESOURCES

President's Council

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PRESIDENT'S COUNCIL ON SUSTAINABLE DEVELOPMENT

vironmental organizations described several successful, cooperative ventures in management of floodplain forests. An oceanographer and a state fisheries biologist also described the increasingly detrimental effects on the Gulf fisheries and shell fisheries of the excess nutrients (phosphorus and nitrogen) delivered by the Mississippi River. The nutrient loading is associated with fertilizer use in the Mississippi watershed and diminishment of nutrient retention resulting from wetland drainage in the floodplains and delta.

The draft report of the Council was released for public comment in July and a national action strategy will be presented to President Clinton in October. Anyone wishing to see the draft report or find out more about the Council should contact:
The President's Council on Sustainable Development
730 Jackson Place
Washington, D.C. 20503
Phone: (202) 408-5340
Fax: (202) 408-6839
E-mail: pcsd@igc.apc.org

Richard E. Sparks, Center for Aquatic Ecology

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NATURAL HISTORY SURVEY

ILLINOIS NATURAL HISTORY SURVEY

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INSIDE

Plants of Oakwood Bottoms

Oakwood Bottoms Greentree Reservoir, located in Jackson County northeast of Grand Tower, Illinois, is part of Shawnee National Forest. The site, which lies in the Mississippi River and Big Muddy River floodplains, was drained by a series of channels and intensively farmed until acquisition by the federal government as part of the national forest. The land came under federal ownership in the 1930s and has been managed since 1964 as a public hunting facility and a timber resource management site.

Photo by Michael Jeffords, INHS Center for Economic Entomology

View of Oakwood Bottoms.

The reservoir site is flooded during the fall and drained before the onset of the growing season. Because the Big Muddy River levee prevents natural flooding of this site, flooding is accomplished by pumping well water. As a result of tight soils and little drainage relief, the area is primarily a wet forest.

In 1976, P.M. Thomson and R.C. Anderson published an ecological investigation of Oakwood Bottoms. Pin oak (*Quercus palustris*), as described by Thomson and Anderson, is the dominant tree species over most of the area. They also recognized five forest community types in Oakwood Bottoms: shagbark hickory, pin oak, black willow, pin oak-cherrybark oak, and pin oak-red maple.

Today, personnel at Shawnee National Forest are conducting intense studies of the forest and carefully recording populations in an effort to better manage the natural diversity of the forest. They have also made a strong commitment to the preservation of threatened and endangered species. As part of this project, the author searched Oakwood Bottoms a total of 24 days between April and November 1993 in an attempt to voucher each species of vascular plant. A total of 511 taxa were collected representing 278 genera and 90 families. The Oakwood Bottoms collection is deposited in the herbarium at the Illinois Natural History Survey.

In the Oakwood Bottoms collection, dicots are best represented, followed by the monocots, ferns and fern allies, and gymnosperms. The grass family (Poaceae) and the aster family (Asteraceae) comprise 24% of all genera and 25% of all taxa within Oakwood Bottoms. Sedge (*Carex*) is by far the largest genus with 34 taxa and it is the primary reason the sedge family (Cyperaceae), with only five genera, is the third largest family of vascular plants (according to total taxa) in Oakwood Bottoms. Also, the grass family and the sedge family together comprise 63% of the monocot genera and 78% of the monocot species.

Despite the heavy impact of farming and drainage control (channels and levees), Oakwood Bottoms has retained an interesting and diverse flora. Three state endangered species, all perennial herbs, were collected: finger dog-shade (*Cynosciadium digitatum*), Arkansas manna-grass (*Glyceria arkansana*), and pole manna-grass (*Puccinellia pallida*). Finger dog-shade was first collected in Illinois in Oakwood Bottoms in 1969. It has not been found elsewhere in

Continued on back page

Aphids and Disease Spread in Crops

Mixed cropping is a cultural control method that can help protect plants from certain aphid-borne virus diseases. Soybean mosaic virus (SMV) and maize dwarf mosaic virus (MDMV) are transmitted in a nonpersistent manner by several species of winged aphids. The transmission of these viruses is termed "nonpersistent" because the virus is both acquired and transmitted in a matter of seconds by a large variety of aphid species that subsequently lose their "charge" or ability to transmit these viruses within an hour. SMV is found wherever soybeans are grown and may cause severe yield losses if early-season spread occurs. Found particularly in areas where johnsongrass occurs, MDMV is one of the most important diseases of sweet corn, resulting in serious yield loss when young plants become infected.

Photo by Gail Kampmeier, INHS Center for Economic Entomology

Researcher Gwen Fondufe weeding soybeans and corn.

To spread, viruses such as SMV and MDMV rely primarily on transient aphid vectors moving through a field. One factor that governs the rate of virus epidemics is the interaction of the aphid vectors with their environment. The overall pattern of vegetation in a field may influence aphid take-off, flight, and landing activity. This includes plant density, canopy cover, crop height and architecture, host plant suitability, and the presence of barrier crops. These relationships are often complex and differ with various aphid species, necessitating a thorough understanding of specific crop/pest interactions when trying to predict the influence of intercropping on a particular pest or disease system.

Companion crops, particularly plants that are not hosts of the virus, effectively slow down the spread of aphid-borne virus diseases. Aphids carrying nonpersistently transmitted viruses tend to lose their infectivity upon probing a nonhost of the virus. It is therefore reasonable to assume that the higher the proportion of nonhost plants of the virus in a crop mixture, the greater the probability that an aphid landing and probing on a nonhost plant will reduce or lose its infectivity, resulting in a proportional reduction of virus incidence.

In a two-year field study, soybean (a nonhost of MDMV) was intercropped in different proportions with sorghum in 1990 and corn in 1991, both nonhosts of SMV. The focus of this study was to understand the influence of varying soybean/cereal mixtures on the incidence of aphid-borne nonpersistently transmitted plant viruses, such as SMV and MDMV, and also on the landing rates of the aphid vectors that transmit them. By identifying the factors underlying virus spread, this study would contribute to the small arsenal of tactics for managing virus diseases and their vectors.

The experiments were conducted in Champaign, IL, during the summers of 1990 and 1991. Four replicates of five different proportions of soybeans and corn or sorghum were planted: (1) soybean monoculture; (2) two rows of soybean to one row of sorghum or corn; (3) one row of soybean to one row of sorghum or corn; (4) one row of soybean to two rows of sorghum or corn; and (5) sorghum (1990) or corn (1991) monoculture.

Aphid landing rates, which give a measure of vector activity within a plot, were monitored with liquid-filled pan traps consisting of a green tile in a plastic sandwich box that was maintained at the crop canopy level. Aphids were collected daily and identified to species under a microscope. Four of the most common species of aphids found during the summer in Illinois field crops, including the corn leaf and melon aphids, were highlighted in this study. Portions of each plot were initially inoculated with SMV or MDMV by airbrushing or rubbing the leaf surface with a mixture of infected plant sap and an abrasive. Natural spread of these viruses by aphids was monitored weekly throughout the growing season by examining plants for symptoms.

Somewhat surprisingly, given that soybeans are not hosts of any species of aphid in the U.S., more aphids landed in soybeans than in either corn or sorghum. In soy-

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Aphids/Disease

continued from previous page

beans, landing rates were generally higher in the mixtures than in the monocultures. Sorghum and corn plants were taller than soybeans throughout the growing season and may have served as barriers, protecting aphids at the soybean canopy from the greater turbulence and higher wind speeds usually experienced in the open monoculture. This protected environment may have encouraged greater flight activity in the crop mixtures. In sorghum and corn, landing rates in the mixtures did not differ significantly from those in the monoculture. Contrary to other reports, intercropping did not reduce aphid landing rates in this study; in fact, in soybeans, intercropping increased landing rates.

However, although aphid landing rates at the level of the soybean canopy were greater in the mixtures, fewer of these soybean plants became infected with SMV than in the monoculture. Although not statistically significant, a similar trend toward a lower incidence of MDMV in corn in the mixtures than in the monoculture was observed, even though aphids tended to land more often in the mixtures than in the monoculture at the corn canopy. Among the mixtures, the incidence of both SMV and MDMV was inversely proportional to the number of nonhost plants of the virus. This inverse relationship was attributed to the increased probability that an aphid landing and probing on a nonhost plant of the virus would lose a substantial amount of its virus charge. Nonhosts of SMV and MDMV in the system played an extremely important role in reducing the spread of both viruses and probably overcame any disadvantage associated with increased aphid landing rates.

Even in extreme epidemic years, the slower accumulation of infected plants in a mixed cropping system can reduce the severity of the epidemic, lessening yield losses and maintaining seed quality, thus decreasing the chances of the virus being carried in seed to the next growing season or from one continent to another. Planting nonhosts of the virus in mixed cropping systems can therefore be recommended as a tactic to help minimize aphid-borne nonpersistently transmitted plant virus epidemics.

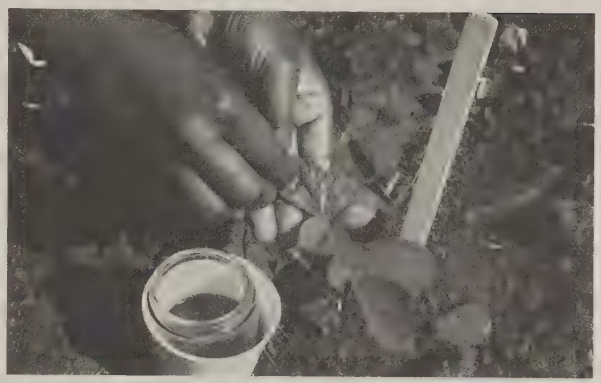

Photo by Gail Kampmeier, INHS Center for Economic Entomology

Innoculating soybeans with SMV.

Gwendolyne Y. Fondufe, Michael E. Irwin, Harry Bottenberg, and Gail E. Kampmeier, Center for Economic Entomology

Identifying Specimens On-line

These days it is not uncommon to reach for a computer, rather than a book, as a first source of information. This was the case for Stephen Mollins, a computer software developer in North Brookfield, Massachusetts. Steve had set up an aquarium of local pond life in his office as part of his strategy to fight the isolation he experienced in his home office environment. Now he wanted to find out about the care and feeding of his new charges. Two of these were "water beetles."

The search of Internet resources began with Yahoo, an on-line commercial searcher available at http://yahoo.com

Steve followed one link to an entomology discussion list maintained by the University of Ontario at Guelph, which he joined. One message on the list was a reply to a request for information about beetles. The reply from an entomologist in Florida said to try http://www.inhs.uiuc.edu/~brigham/my_home.html

This is the water beetle home page I maintain on the World Wide Web (WWW). A home page can be many things. Mine is a source of information contained in text files and "hot links" that take the user to other sites throughout the world to access additional text files, images, and databases on related topics. One hot link on my home page activates the user's electronic mail software to send comments directly to me. Steve used this function to ask me about the food requirements, longevity, and identity of his beetles.

Steve's description of the first beetle and its swimming habits suggested that it was a whirligig beetle. These beetles are the size

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Scanned image of water boatman exchanged over the Internet. (Image courtesy of Stephen P. Mollins.)

The Round Goby Invades Lake Michigan

The latest exotic species to invade the Great Lakes is a diminutive fish from the Black and Caspian seas area. The round goby, which grows to only 10 inches long, was discovered in 1990 in the St. Clair River, which borders the U.S. and Canada near Detroit. For three years they remained within a few miles of their point of introduction, but in January 1993, several gobies were caught by anglers in the Grand Calumet River in Indiana. By 1994 they were found in Calumet and Hammond harbors, IL, South Haven, MI, and Cleveland, OH; and in 1995 gobies were found on the north side of Chicago and in Duluth, MN. This rapid spread was undoubtedly facilitated by the same vector that brought gobies to North America — ballast water transfer from ocean-going ships in the Great Lakes. The presence of gobies in the Calumet River means that they have direct access to the Illinois and Mississippi river drainages, and thus to a large geographic range.

Photo by Ellen Marsden, INHS Center for Aquatic Ecology

Round goby, small but troublesome exotic fish in the Midwest.

The reaction of scientists and fisheries managers to the round goby has been different than has been the case with other recent invaders. When zebra mussels were found in Lake St. Clair in 1988, they were immediately recognized as an ecological threat because of their centuries-long history of disrupting native communities and fouling intake pipes as they spread across western Europe. The appearance of European ruffe in Lake Superior near Duluth in 1987 raised similar alarms because ruffe had invaded Loch Lomond in Scotland a decade earlier and nearly wiped out the local populations of yellow perch. In contrast, when the round goby appeared in the St. Clair River, no one paid much attention. Round gobies had not previously spread beyond their native range, so they had no history of causing problems. This has been an unfortunate case of assuming innocence until guilt is proven — an unwise strategy where exotic species are involved. Many exotic species that have become established in North America (and the rest of the world) have caused significant ecological disruption (consider cockroaches, starlings, Norway rats, dandelions, and the Medfly).

Round gobies are relatively small, benthic, soft-bodied fishes that are easily confused with native sculpin species. Two characteristics may be used to distinguish them from the natives: first, their pelvic fins are fused to form a disk. This pelvic disk is characteristic of the goby family. Second, their bodies are covered with fine, mail-like scales, in contrast to the local native sculpins, which are naked or sparsely covered with prickles. Round gobies also have a distinctive black spot on the spinous (front) dorsal fin, but this character is not diagnostic for gobies because many sculpins have a similar spot in the same location.

Although there are a few euryhaline (able to tolerate a wide range of saltwater concentrations) marine gobies that are often found in coastal streams, the round goby is the first freshwater goby to proliferate in North America; the tubenose goby, which appeared in the St. Clair River at the same time as the round goby, has not spread widely. Round gobies are more fecund, more aggressive, and have lateral line systems that are more sensitive in still water than those of the native sculpins. Round gobies are natural predators of zebra mussels in their native eastern European range, and a substantial proportion of their diet in the Great Lakes is composed of zebra mussels; sculpins eat few zebra mussels. These features of the goby suggest that round gobies probably will be able to invade many regions of the Great Lakes, and may displace native sculpins by outcompeting them for shared resources of food and habitat.

Another feature that gobies share with sculpins is their ability to deeply penetrate the interstitial spaces in cobble substrates. For sculpins, this behavior makes them an effective predator of lake trout eggs. Lake trout were extirpated in Lake Michigan by the 1950s and are currently the focus of a massive stocking effort with the aim of population rehabilitation. The trout spawn in fall over cobble reefs and their eggs settle deeply into interstitial spaces, where they are mostly protected

Continued on next page

Round Goby

continued from previous page

from storm-generated surges and from predators—except sculpins. Stocked lake trout are just beginning to spawn, in low numbers, in Lake Michigan (see INHS Reports 324); the addition of a new, highly abundant egg predator could mean a significant setback for their rehabilitation.

Gobies have not yet spread into areas where lake trout spawn, though they are within 15 miles of an important lake trout spawning site. However, in our laboratory experiments, which simulated conditions on a lake trout spawning reef, gobies readily retrieved and consumed eggs that had settled into cobble substrates. They also ate newly hatched fry under the same conditions. Gobies as small as 56mm, which are likely only one year old, could break and eat lake trout eggs. The largest gobies tested, which were 100-120mm long, ate over three eggs per day on average. By comparison, sculpins tested under similar conditions ate an average of two eggs per day, as did crayfish. Estimates of sculpin densities in the Great Lakes vary from 1 to 30 per square meter; densities of adult gobies near Calumet Harbor in Lake Michigan vary from 1 to 20 per square meter, and juveniles are present on sandy substrates at 8 to 133 per square meter.

Clearly, gobies have both the potential population densities and the appetite to pose a serious threat to lake trout reproductive success. Whether this threat will be realized depends on how rapidly gobies spread to lake trout spawning areas, and their preference for alternate food sources. Native fish species, including adult lake trout, are likely to prey upon gobies, although the gobies' sensitive lateral line system makes them highly effective at detecting and avoiding predators. For example, sculpins can be easily collected by scuba divers with a dip net, whereas gobies larger than 27mm are extremely difficult to catch. Gobies are only too easy to catch with a rod and reel, however; anglers in the St. Clair River and Calumet Harbor have been frustrated by the gobies' propensity to steal bait.

Like the other exotic species that have invaded the Great Lakes in recent decades, gobies have become a permanent part of the ecosystem; they are too numerous and too widespread to control. A few of their potential impacts are predictable: competition with sculpins, and predation on lake trout eggs and fry and other benthic organisms. Whether they will become a significant nuisance like the ruffe or alewife remains to be seen, and this possibility will be the focus of research by Survey investigators over the next few years.

J. Ellen Marsden and Michael A. Chotkowski, Center for Aquatic Ecology

Specimens

continued from page 3

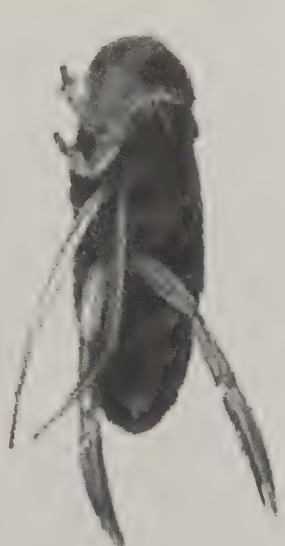
and shape of black watermelon seeds, and often occur in swarms, whirling about on the surface of ponds and streams. I e-mailed back a description of each of the two genera known from Massachusetts, and Steve confirmed that his was a *Gyrinus*.

The second "beetle" was not so easy because the description Steve originally provided could apply to many insects. I asked Steve to send additional information regarding its size, shape, swimming behavior, method of obtaining air, and so on. His response included an interesting twist. One of these insects had died. Steve dried it with a tissue, placed it on his desktop scanner under a piece of paper, scanned it at 400% size, and then played with the contrast and brightness until the image was as clear as possible. Steve's daughter Tiffany, a high school senior, had developed a home page for Steve on the WWW. She suggested putting the image on his page so that I could look at it.

The image was clearly that of a water boatman—a bug, not a beetle—belonging to the family Corixidae. I copied the images to my computer, enlarged them by about double, and sharpened them to check details. These suggested the genus *Sigara*.

Entomologists once had the luxury of sufficient funds to conduct field work where it was needed. As funding declined, they began to rely more heavily upon specimens in museums, such as the one maintained at the Survey. Borrowing insects, however, subjects these fragile and often unique specimens to damage or loss. My interaction with Steve to identify his insects documents an entirely new concept for providing access to specimens. "Virtual specimens" can be placed before specialists by those who need the information they can provide. This represents a first step toward a new way to "exchange" specimens that involves no risk to the specimens and is fast (the entire exchange of electronic documents with Steve took place during a single morning). It is yet another example of public institutions "without walls."

Warren U. Brigham, Office of the Chief



Scanned image [side view] of water boatman exchanged over the Internet. (Image courtesy of Stephen P. Mollins.)

Species Spotlight

The Common Stoneroller

Susan Post

The common stoneroller, *Campostoma anomalum,* is a dusky-colored minnow with scattered brown or black scales along its sides. This coloration helps it to blend in with its habitat—streams that have gravel, bedrock, or a mix of sand and gravel bottoms. The common stoneroller can be found throughout Illinois where these stream habitats occur. Stonerollers are lacking from the clay- or mud-bottom streams in the south-central part of the state. As a species, stonerollers are fairly intolerant of silt and disappear from degraded streams.

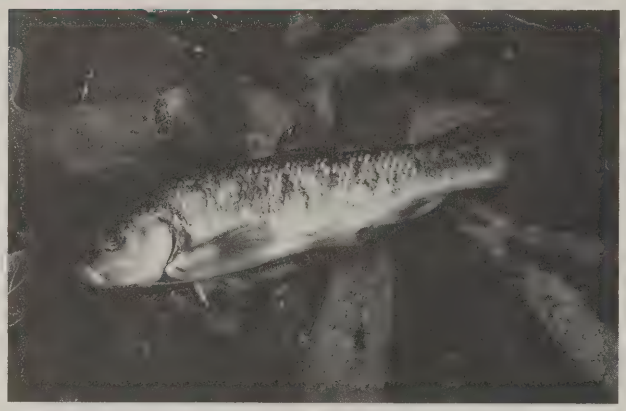


Photo by Michael Jeffords, INHS Center for Economic Entomology

Common stoneroller (Campostoma anomalum).

The common stoneroller ranges in size from 3 to 6.5 inches long and its snout is bluntly rounded and protrudes slightly beyond the mouth. The best diagnostic characteristic, unfortunately, requires the death of the fish. Common stonerollers differ from all other minnows in that their intestines are extremely long and spiral around their air bladders.

Stonerollers feed on algae, plant tissue, zooplankton, and the brown slime found on rocks and logs. The fish's lower jaw has a hardened, gristly edge that enables it to scrape surfaces for slime and scum.

During September and October the males develop tubercles. These tubercles are slightly hooked, whitish bumps that range from large near the head to small on the body and fins. They are used to help defend the fish's territory, for protection during digging in the gravel, and as an aid in grasping the spawning female. Shortly after spawning the tubercles are lost.

When the water temperature reaches 60° F the males begin nest construction. The nest site requires a gravel bottom and moderately shallow, clear water with a deeper pool nearby. The males have three distinct nest-building behaviors: picking, where the male takes a pebble in its mouth, brings it to the edge of the nest pit, and then releases it; digging, where the male pushes its head down into the nest pit and swims into the gravel with a writhing movement that loosens the gravel; and pushing, where the male places its snout against a stone and swims into it. Stoneroller nests are irregular in outline, are several inches across, and are often used by several males.

While the males are diligently engaged in nest-building, females "hang out" in schools 5 to 30 feet away from the nest-building area. When a female is ready to spawn she will move into the nest area. Her eggs will become lodged in the gravel, are fertilized by a male, and are then abandoned. Fertilized eggs hatch within 72 hours.

Teacher's Guide to "The Naturalist's Apprentice" (facing page)

Humans Aren't the Only Architects

Objective: to learn about a few of the structures (nests) animals build

Materials: multiple copies of **Humans Aren't the Only Architects**

Comments: Birds do it, mammals do it, fishes do it, reptiles do it, even insects do it. What are we talking about? Why, nestbuilding, of course. The encyclopedia defines a nest as "a place chosen or a structure built by an animal for shelter or concealment, usually for the reception of the eggs or young and as a home for the young during their early development." While this rather dry statement may be true, it falls far short of describing the remarkable diversity and ingenuity of animal architects. Nests range from simple depressions scooped out on the bottom of a stream by some fish to incredibly elaborate, woven structures produced by certain birds, such as orioles. Even insects get in the act. That bothersome paper structure under the eaves of your house is a paper wasp colonial nest in which hundreds of new wasps are produced each season.

Procedure:

1. Introduce the subject of nest building by animals with the material presented above and in *Species Spotlight.*

2. Distribute copies of **Humans Aren't the Only Architects** and have students match the organism in column 1 with the correct nest picture in column 2. *Answers: A-J; B-I; C-F; D-G; E-H.*

3. Have students try to name other animals that construct nests.

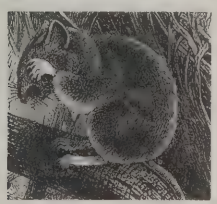
Many animals make remarkable structures in which to live and to rear their young. Match the animal in column 1 with the correct nest it has built in column 2.

Column 1

A

B

C



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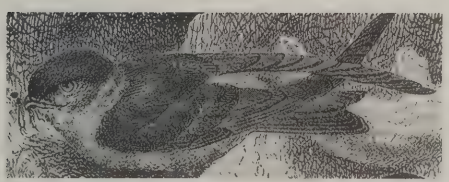

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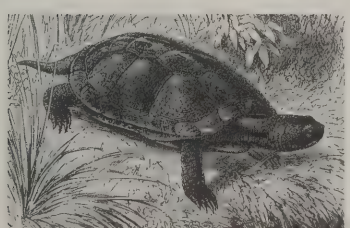
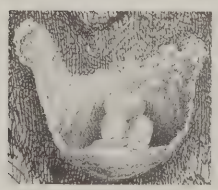


Column 2

F

G



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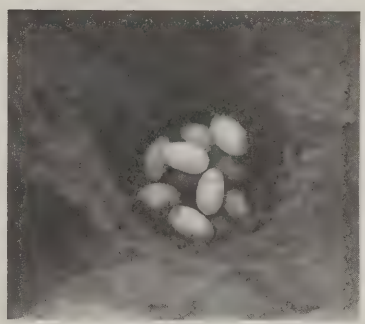

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Oakwood Bottoms

continued from front page

the state and this rediscovery of finger dog-shade in Oakwood Bottoms is the first verification of its persistence at this site. Between 1,000 and 2,000 plants were observed during this study, all in the southern portion of Oakwood Bottoms. Arkansas manna-grass and pole manna-grass were both previously known only from Union County in a floodplain swamp along the Big Muddy River. About 50 plants of Arkansas manna-grass in one population were found in the southwest portion of Oakwood Bottoms and three populations totaling about 200 plants were found in the northern part of Oakwood Bottoms.

Two species discovered in Oakwood Bottoms, not commonly found in their respective ranges, include Wolf's sedge *(Eleocharis wolfii)* and lake cress *(Armoracia aquatica)*. Wolf's sedge is currently designated by the U.S. Fish and Wildlife Service as a "candidate under review" for inclusion in its list of endangered and threatened species. Hundreds of plants of Wolf's sedge were found in Oakwood Bottoms. Six plants of lake cress were found in one population in Oakwood Bottoms. Two species, swamp red iris (*Iris fulva*) and mock bishop's weed (*Ptilmnium costatum*), which had been listed previously as Illinois endangered and threatened species, were found scattered throughout Oakwood Bottoms. A few additional infrequently encountered plants for southern Illinois were found in various locations within Oakwood Bottoms. They include hornwort (*Ceratophyllum echinatum*), manna-grass (*Glyceria septentrionalis*), marsh vetchling (*Lathyrus palustris*), smooth-flowered muhly (*Muhlenbergia glabriflorus*), unusual fescue (*Festuca paradoxa*), and water purslane (*Didiplis diandra*).

Data from the current completed study has been forwarded to the U.S. Forest Service. This information will provide a baseline against which the Service can compare future inventories as it continues to monitor and study Oakwood Bottoms. Without a thorough inventory it has not been possible to gauge the effects of agriculture on the florisitc diversity of the Bottoms. Such trends will now be possible to discern using data collected in this study.

Loy R. Phillippe, Center for Biodiversity

Photo by Ken Robertson, INHS Center for Biodiversity

Red iris (Iris fulva) found in Oakwood Bottoms.

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